ecological land classification and evaluation

Alberta

ECOREGIONS OF ALBERTA

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PREFACE

Since 1969, the Resource Appraisal Section of the Resource Evaluation and Planning Division, Alberta Energy and Natural Resources, and its predecessor, the Land Use Assignment Section, has prepared a number of Ecological Land Classification reports. In these reports ecoregions were established without the aid of a key map for the Province. Acceleration of the work, and particularly our endeavors in the "Eastern Slopes", called for the preparation of an ecoregion map for Alberta. The establishment of the Climatology Unit in the Section provided the catalyst and expertise necessary to compile information for the production of an ecoregion map and accompanying report. Requests from the Section's staff and others clearly indicated that this work was necessary. Mr. Wayne Strong, ecologist, and Mr. Keith Leggat, climatologist, were formally assigned to this project, although other staff members contributed both information and criticism.

Outlined ecoregions provide the first level of Ecological Land Classification. This report describes the representative vegetation, characteristic climate, and soils for each ecoregion. In addition, it identifies some of the common ecological deviations.

The report was initially intended as an in-house document; however, its content and documentation makes the report suitable as an information source for many resource agencies.

ACKNOWLEDGEMENTS

The authors thank the following persons for their contributions to this report.

Contributor	Contribution
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The interpretations contained within this report may not necessarily be in agreement with the interpretations of those persons listed above.

INTRODUCTION

The term ecoregion is a noun derived from "ecosystem" and "region", literally an ecological system found on a given area of land. In practice the term refers to an ecosystem which characterizes a large geographical area and is intended to be a broad level of generalization for classification of landscapes. An ecoregion is defined as "an area characterized by a distinctive regional climate as expressed by vegetation" (Subcommittee on Biophysical Land Classification 1969). Vegetation responds to different regional climates by altering species composition, physiognomics, and successional patterns.

Ecoregions are usually of large areal extent and can be conveniently mapped at a scale of 1 cm to 10 km (R.F. 1:1,000,000) to 1 cm to 30 km (R.F. 1:3,000,000). Recognition and mapping of large ecosystems is difficult because vegetation and climatic variation may be nearly as great within ecosystems, as it is between ecoregions. However, there is an essence of unity within any one ecoregion. In one sense an ecoregion may be viewed as a transition zone between adjacent ecoregions.

The identification and classification of Alberta's regional climate and vegetation has been attempted by many researchers (e.g. Sanderson 1948, Rowe 1972, Powell and MacIver 1977). Most of these works were probably hindered by limited access, uneven distribution of data, insufficient data, or a single disciplinary focus.

The intent of this work is to delineate and characterize the various ecoregions of Alberta. For convenience a mapping scale of 1:1,500,000 was selected. Mapped units were identified by natural vegetation, climate and to a lesser extent, soils. These mapped units will form the first level of ecological land classification and evaluation by the Resource Appraisal Section, Alberta Energy and Natural Resources. Subsequently, more detailed classifications of Alberta's landscape will be tied to this broad framework. Many of the more detailed classifications are conducted at an R.F. of 1:100,000. These are intended for multi-disciplinary planning and management of Alberta's landscape and natural resources.

In addition to its primary function as the first level of classification, the ecoregion framework will form the first level of evaluation. This evaluation will consider the climatic suitability of the various ecoregions to support land use activities such as agriculture, tree growth, outdoor recreation, and wildlife (see Resource Evaluations). Although climate represents but one component of the environment, many conclusions can be drawn from the climatic data that have implications at lower levels of ecological analysis.

The authors' attempt at recognition and description of Alberta's ecoregions is only the first step in developing a sound ecoregion framework. As the first step it will provide the basis for future ecological work. As more climatic and ecological data become available, and the ecoregion boundaries and concepts are tested, refinements to this model will be developed.

HISTORICAL AND MODERN PERSPECTIVE OF REGIONAL ECOLOGICAL WORK

A need for a regional perspective of Alberta's environment is not new. Palliser (1863) was one of the first to formally attempt an inventory and evaluation of Alberta's ecological setting. Since this early work many attempts have been made at this task, each with its own particular orientation and philosophy. With the passage of time more data have become available which theoretically implies that an increasingly sophisticated mapping and classification scheme would develop. This has not always been the case. Regional thematic maps and classification schemes have become numerous in the last 10 to 15 years, thus suggesting a need for a synthesis of all previous work.

Numerous single disciplinary or thematic maps have been developed as a basis to evaluate Alberta's ecology. Maps of vegetation (Moss 1955; Government and University of Alberta 1969; Rowe 1972; and Bird and Hong 1975), soils (Government and University of Alberta 1969), insects (Strickland 1938), and climate (Sanderson 1948; Bowser 1967; Government and University of Alberta 1969; and Powell and MacIver 1977) are scattered throughout the ecological literature of Alberta. Each has a somewhat unique classification system and function, and set of mapping units. Some of this work is more ecologically oriented than others. Although it is understood that variation does occur in individual maps and classifications due to differences in interpretation and function, there does not appear to be one single source developed to date which provides an ecological perspective of the entire province. The methods and nomenclature used to develop these maps were seldom tied to a national system such as that sanctioned by the Canada Committee on Ecological Land Classification.

Presently, four inventory and classification programs are in progress within Alberta that have some similarities

to the ecoregion analysis presented within. The first is a classification and mapping scheme prepared by Alberta Recreation and Parks (1979) for the purpose of stratifying and selecting ecological reserves. This map is at a scale of 1:1,000,000 with broad categories defined on the basis of vegetation, soils, physiography, and climate. A second ecological mapping program is a detailed evaluation within Banff and Jasper National Parks (Holland 1976). The bioclimatic zones of that program are equivalent to ecoregions. Much of the mapping associated with this project is at a scale of approximately 1:50,000 with the work intended for the planning and management of the National Parks. A third ecological classification is the biogeoclimatic analysis of Alberta's forested lands. A biogeoclimatic zone map will be produced at a scale of 1:2,000,000 (Kojima and Krumlik 1979). Initially, there may appear to be a distinct duplication between that work and this analysis; however, the biogeoclimatic project is oriented strictly towards forest operational management (scale 1:15,000 or larger). Their zonation map will provide a general framework within which forestry management schemes are developed (Kojima and Krumlik 1979). A fourth project is being developed by the National Ecoregion Committee of the Canada Committee on Ecological Land Classification. Their objective is to construct an ecoregion map of Canada at a scale of 1:5,000,000. This project is expected to be completed by mid 1981.

METHODS

Various methods were used to identify and map the ecoregions. Much of the work relied upon existing data supplemented with field and aerial reconnaissance. Published works by such ecologists as Rowe (1972) on forested areas, and Moss (1955) and Coupland (1950, 1961) on grassland areas, provided a basic ecological framework. A number of other ecological reports were consulted. These were interpreted and formed baseline data around which ecoregions were delineated. Amongst the primary data sources were forest cover maps, Landsat and conventional aerial photography, soil reports, and climatic data.

Ecoregions were recognized and delineated on the basis of recurring vegetation, soil, and moisture sequences. This approach is similar to the concepts applied by Hills (1959, 1961) in Ontario and later expanded upon for the Canada Committee on Ecological Land Classification (Hills 1976). The vegetation that occurred on a moderately well drained, medium textured substrate formed the "modal" condition of the ecoregion. Wetter or drier vegetation types (semi-stable seral stages) were arranged relative to the modal condition, and to each other.[1] One basic deviation from Hill's approach was the reduced concern given to succession and increased emphasis on the existing vegetation. The approach was felt to provide a correlation and organization of the ecological information from each ecoregion into smaller and more easily recognized ecosystems for comparison between and within ecoregions.

In addition to existing vegetation, secondary successional species (i.e. spruce and fir) were used as criteria to separate ecoregions. The reasons why one species is successional in one ecoregion and not another may not be completely understood, but it may have management implications.

Although ecoregions are an expression of climate, they cannot be identified by climate alone. A purely statistical classification of climate (Powell and MacIver 1977) allows the data to identify the classification criteria. The problem with this type of approach is that the classification boundaries may not coincide with ecologically significant vegetation boundaries. Powell and MacIver's (1977) classification does supply valuable information on climatic behavior in the ecoregions defined here. Furthermore, climate cannot be used for ecoregion delineation because the density of stations is often too sparse and ecologically significant parameters are not always known. Climatic analysis was used to adjust uncertain or tenuous boundaries where possible.

Once preliminary ecoregion lines were delineated, the climate data within each were tabulated and summarized. The intent was to characterize the climate of the various ecoregions and to determine the differences. The data were gathered from the Atmospheric Environment Service, Environment Canada, the Alberta Forest Service, J.M. Powell, and published literature (Table 2; Appendix I). The Atmospheric Environment Service is the major climate data collector in the province. However, as they use volunteer observers, the network has been concentrated in the settled portions of the province. The Alberta Forest Service is the principal climate data collector in the forested areas. These data have limitations as they mostly operate during summer and are often in areas of complex terrain. The result is an uneven distribution of climate stations with variable amounts of data over different time intervals. Climatic maps (Powell and MacIver 1978) were used in areas of complex topography or few climate stations.

The 1941 to 1970 normals were used where available for all parameters except snow cover, chinooks, and Sacramento gauge precipitation.[2] Temperature and precipitation

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[1] The relative arrangement of each seral stage was not intended to be a successional sequence, although similar sequences may exist. If succession were to be portrayed it could be on the vertical axis rather than the horizontal.

[2] Precipitation accumulated in Sacramento gauges is measured only twice a year (October 1 and May 1).

records of 10 to 24 years had been adjusted to yield values close to true normals (Aston and Kendall 1972). J.M. Powell supplied unpublished data on killing frosts for the 1961-1970 period.

Two types of statistics were examined when characterizing the climate of the various ecoregions. They were a measure of central tendency (i.e. mean or mode) and the range (i.e. between extreme stations). The first step was to order by recording station and ecoregion all relevant data into arrays. The climate parameters investigated were chosen on the basis of their importance to a wide variety of biological activity and land uses, and their availability through published sources. The parameters used were:

- mean temperature (May to September, December to February, and annual).
- total precipitation (May to September, October to April, and annual).
- freeze free period.
- number of days with sub-freezing temperatures (May to September).
- growing degree days greater than 5° C (May to September).
- number of days with precipitation (May to September and annual).
- number of days with snow cover.
- mean maximum winter depth of snow.
- number of days with chinooks (December to February).
- climate moisture budgets (May to September) based on Thornthwaite and Mather (1957).
- hours of bright sunshine.

The tabulated data allowed for the direct comparison of climatic factors, and the selection of factors which distinguish an ecoregion from adjacent ecoregions. Further information on climatic processes such as storm tracks and elevation effects were added for further insight to the climate of the ecoregions.

ECOREGION DESCRIPTIONS

Three major climatic regimes or ecoprovinces, occur within Alberta; Prairie, Cordilleran, and Boreal. The interaction of these major climatic regimes influences the heat and moisture availability characteristics of the 12 ecoregions in Alberta. The major climatic regimes are modified by factors such as latitude, elevation, continentality, and storm tracks. These ecoregional climates are represented by modal ecosystems which are created by both abiotic and biotic factors. The following sections describe the ecoregions of Alberta in terms of their characteristic climate, vegetation, and soil.

Ecoregion 1 – Short Grass

The Short Grass Ecoregion is located in the southeastern corner of Alberta. It covers approximately 47 000 km^2, or 7.1% of the province, making it the largest grassland region in Alberta (Table 1; Figure 1; Map 1). Much of this ecoregion has been altered by agricultural practices. As a result the Brown Chernozem soil zone was used to delineate the Short Grass Ecoregion (Wyatt, Bower, and Odynsky 1939; Wyatt *et al.* 1943; Peters and Bowser 1960a; Bowser, Peters, and Kjearsgaard 1963; Kjearsgaard 1976).

This ecoregion has a continental Prairie climate characterized by cold winters, warm summers, and low precipitation. Both summer and winter precipitation are the lowest in the province. These conditions result from major storm tracks being located south of the area during the winter (December to February, inclusive) and to the north during the summer (May to September, inclusive). The interior continental location of this region is responsible for a wide range in diurnal temperatures during summer. Elevation and low latitude are also significant factors in creating the climate of this region. Climatic recording stations at Pollockville, Scotfield, and Suffield best represent the modal climate conditions of this area (Appendix 1).

Table 1
APPROXIMATE AREAL EXTENT OF ECOREGIONS IN ALBERTA

Ecoregion Name	Ecoregion Number	Percent Area	km^2
Short Grass	1	7.1	46 926
Mixed Grass	2	4.7	31 063
Fescue Grass	3	2.2	14 403
Aspen Parkland	4	11.1	73 268
Montane	5	0.5	3 538
Subalpine	6	3.5	23 133
Alpine	7	2.8	18 506
Boreal Mixedwood	8	43.2	285 611
Boreal Foothills	9	9.6	63 362
Boreal Uplands	10	4.1	27 098
Boreal Northlands	11	7.2	47 588
Boreal Subarctic	12	4.0	26 437
TOTAL		100.0	660 933

CLIMATIC CONDITIONS

The Short Grass Ecoregion has the lowest mean summer precipitation (210 mm) of any ecoregion in Alberta; the range is 170 to 250 mm (Table 2). The mean yearly precipitation is 340 mm with a range of 260 to 380 mm. These

Table 2

ECOREGION CLIMATE DATA SUMMARY[3,4]

MAY TO SEPTEMBER

Ecoregion	Mean Temperature °C			Growing Degree Days Above 5 °C			Freeze Free Period			Number Days 0 °C or Less			Total Precipitation (mm)				No. of Days Precipitation 0.2 mm or More			Climatic Moisture Deficit		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Percent of Annual	Mean	Max.	Min.	Mean	Max.	Min.
Short Grass	15.0	16.0	14.5	1570	1750	1380	115	125	100	10	15	5	210	250	170	64	35	40	25	-300	-350	-260
Mixed Grass	14.5	15.0	13.5	1440	1610	1290	110	125	85	15	25	10	260	290	200	65	40	45	30	-240	-300	-200
Fescue Grass	12.5	13.5	11.0	1210	1330	950	90	110	25	20	50	15	290	370	230	61	40	55	30	-170	-200	-100
Aspen Parkland	13.0	15.0	10.0	1260	1400	850	95	125	35	20	45	10	300	400	250	67	50	60	35	-160	-220	-30
Montane	11.5	12.0	10.5	1030	1120	920	75	85	55	30	40	20	270	390	110	50	50	60	35	-160	-240	-40
Subalpine	9.5	10.5	8.0	810[3]	930	710	15[2]	15	15	60[4]	65	50	320	430	180	51	50[4]	60	50	-110[2]	-140	-80
Alpine	6.5	7.5	4.0	–	–	–	–	–	–	10	10	10	360	430	270	48	–	–	–	–	–	–
Boreal Mixedwood	12.0	14.0	10.5	1190	1310	970	85	120	50	20	30	10	300	440	200	72	55	65	35	-190	-270	-100
Boreal Foothills	11.5	12.5	10.0	1080	1140	1020	80	105	50	25	60	10	370	450	230	66	60	65	50	-70[4]	-90	-20
Boreal Uplands	10.0	11.5	8.5	740[1]	740	740	75	105	20	30	65	15	380	470	290	62	60	70	55	-20[2]	-30	-10
Boreal Northlands	11.0	12.0	10.0	1050[3]	1080	1010	85[3]	105	65	25	30	25	250	340	180	55	50[4]	55	45	–	–	–
Boreal Subarctic	10.0[3]	10.0	9.5	–	–	–	–	–	–	–	–	–	300[1]	300	300	–	–	–	–	–	–	–

[3] Superscripts indicate the number of stations when less than 5.

[4] Sources: Alberta Forest Service, 1978, Atmospheric Environment Service 1975a, b; Aston, 1975; Hemmerick and Kendall 1972; Longley 1967; and Potter 1965.

Table 2 continued[3,4]

Ecoregion	DECEMBER TO FEBRUARY						WINTER SEASON						OCTOBER TO APRIL			ANNUAL								
	Mean Temperatures °C			No. Days with Chinooks			No. Days with Continuous Snow Cover			Maximum Depth of Snow Cover (cm)			Total Precipitation			Temperature °C			Total Precipitation			No. Days Precipitation 0.2 mm or More			Hours of Bright Sunshine		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
Short Grass	-10.5	-8.0	-13.5	20	35	10	95[2]	100	85	25[2]	30	25	120	150	80	4.0	5.5	2.5	340	380	260	70	90	45	2310[2]	2460	2170
Mixed Grass	-10.0	-6.0	-15.0	20	35	5	105[2]	130	80	35[2]	45	25	140	190	90	4.0	5.5	1.0	400	470	300	75	105	55	2390[1]	2390	2390
Fescue Grass	-8.0	-6.0	-12.5	30	35	15	95[2]	100	90	30[2]	35	25	230	500	120	3.5	5.0	2.0	520	870	370	90	115	70	2210[1]	2210	2210
Aspen Parkland	-12.5	-7.0	-16.0	10	30	5	135[4]	150	120	40[2]	55	30	160	400	100	2.0	3.5	0.0	450	710	390	95	130	60	2210	2360	2090
Montane	-7.5	-6.5	-9.5	20	30	10	145[2]	155	130	50[2]	50	50	300	480	170	3.0	4.0	2.5	560	810	280	105	130	80	1740[1]	1740	1740
Subalpine	-9.0	-7.5	-12.0	15[2]	30	5							400	830	170	1.5	2.5	0.0	720	1230	350	120	135	100			
Alpine	-14.0[1]	-14.0	-14.0	–	–	–	–	–	–	–	–	–	400	590	240	-4.5[1]	4.5	-4.5	730	970	570						
Boreal Mixedwood	-15.5	-11.5	-23.0	10	20	<5	150	155	140	50	55	45	170	250	120	0.5	3.0	-3.0	440	520	350	105	135	60	2060[4]	2340	1840
Boreal Foothills	-10.0	-8.0	-12.5	20[4]	25	10	145[1]	145	145	45[1]	45	45	240	350	170	2.0	3.0	1.0	570	670	510	110[4]	125	90	2000[1]	2000	2000
Boreal Uplands	-10.5	-8.5	-12.5	10[1]	10	10	–	–	–	–	–	–	220	300	160	1.0	1.5	-0.5	580	740	440	105[2]	110	110			
Boreal Northlands	-24.0[3]	-23.5	-24.5	–	–	–	185[1]	185	185	55[1]	55	55	160[3]	170	140	-3.5	3.5	-4.0	340[3]	450	300	120[2]	130	115	2040[1]	2040	2040
Boreal Subarctic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

[3] Superscripts indicate the number of stations when less than 5.

[4] Sources: Alberta Forest Service, 1978, Atmospheric Environment Service 1975a, b, Aston, 1975, Hemmerick and Kendall 1972, Longley 1967, and Potter 1965.

Figure 1.
Location of Short Grass Ecoregion.

characteristics can be used to distinguish this ecoregion from the adjacent Mixed Grass Ecoregion. The boundary between these two ecoregions is approximated by the May to September 230 mm isohyet (Figure 2).

Although the Short Grass Ecoregion can be distinguished from other ecoregions by May to September precipitation, it also has unique temperature characteristics. The mean May to September temperature is 15.0°C with a range from 14.5° to 16.0°C. The warmest month is July with a mean temperature of 18.5°C and a range of 17.5 to 20.0°C. Thus it has the warmest summer conditions of any ecoregion in the province.

The high summer temperatures, low precipitation, strong winds, and high insolation combine to produce high potential evapotranspiration values and a large climatic moisture deficit (subarid to semiarid). The mean climatic moisture deficit is approximately 300 mm, ranging from 260 to 350 mm throughout the ecoregion. This is the highest of any ecoregion in the province (Table 2). There is a distinct maximum during July and August.

Accumulated growing degree days above 5°C during the summer range from 1380 to 1750 with a mean of 1570. The warm summer temperatures also result in mean freeze free periods over 100 days in length throughout this ecoregion. Heat and length of growing season are not limitations for agriculture relative to the rest of the province, but the moisture deficiency is a severe limiting factor.

Several aspects of winter climate are worth noting. This ecoregion has shallow snow depths and relatively few days with continuous snow cover. The cold mean winter (December to February) temperatures (-10.5°C) when coupled with shallow snow cover leads to very harsh winter conditions for vegetation. The mean January temperature for the area is -13.5°C. The southwest corner of this ecoregion receives an average of 35 chinook days per year, but the remaining area receives 10 to 20 chinook days.[5] This ecoregion has the lowest mean October to April precipitation in the province.

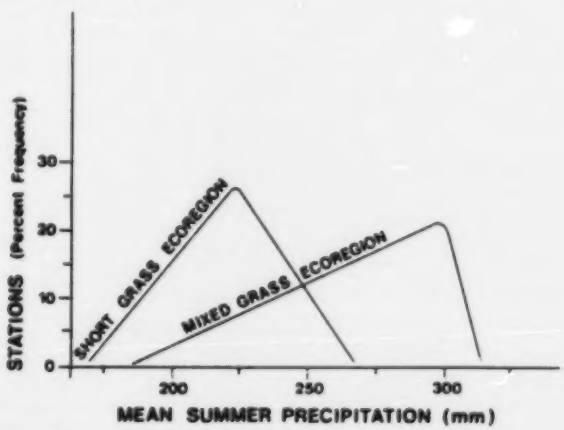
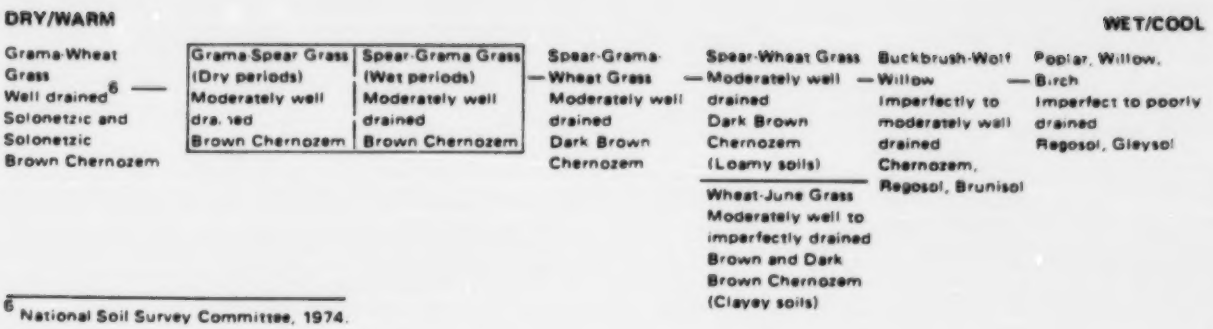


Figure 2.
Percent Frequency of Mean Summer Precipitation Classes in the Short Grass and Mixed Grass Ecoregions.

ECOLOGICAL CONDITIONS

The Short Grass Ecoregion has been recognized by several ecologists (Clarke, Campbell and Campbell 1942; Hubbard 1950; Coupland 1952; Wroe *et al.* 1979), although

[5] A chinook day is defined as one with the daily maximum temperature above 4°C from December to February (Longley 1967).


DRY/WARM
WET/COOL
Grama-Wheat Grass Well drained[6] Solonetzic and Solonetzic Brown Chernozem
Grama-Spear Grass (Dry periods) Moderately well drained Brown Chernozem
Spear-Grama Grass (Wet periods) Moderately well drained Brown Chernozem
Spear-Grama-Wheat Grass Moderately well drained Dark Brown Chernozem
Spear-Wheat Grass Moderately well drained Dark Brown Chernozem (Loamy soils)
Wheat-June Grass Moderately well to imperfectly drained Brown and Dark Brown Chernozem (Clayey soils)
Buckbrush-Wolf Willow Imperfectly to moderately well drained Chernozem, Regosol, Brunisol
Poplar, Willow, Birch Imperfect to poorly drained Regosol, Gleysol

[6] National Soil Survey Committee, 1974.

Figure 3.
Short Grass Ecoregion – Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box. (Interpreted from Coupland 1950, 1952, 1961).

they may have used different names. The plant species of this ecoregion reflect the severe summer moisture deficit that occurs during mid to late summer. Grama grass with secondary occurrences of spear grass represent the characteristic vegetation.[7] During wetter periods of climatic cycles, spear grass increases in cover. This modal vegetation is typically found on medium textured, well to moderately well drained, Brown Chernozem soils.[8] Other plants such as little club-moss, sagewort, moss phlox, and sedges are also common floral components of the vegetation (Picture 1). The flora of the Short Grass Ecoregion is adapted to the late summer aridity. Plants such as grasses and sedges become dormant while others complete their life cycle prior to the late summer drought.

Figure 3 illustrates the distribution of ecosystems along an environmental gradient. These ecosystems grade from the modal community, Grama-Spear Grass, to wetter and drier conditions. In general, as moisture decreases grama grass becomes more common and spear grass declines in abundance. However, spear and wheat grasses increase in abundance as moisture availability increases (e.g. north aspects where evapotranspiration is reduced). Shrub communities composed of buckbrush and wolf willow occur on moist sites such as seepage areas and depressions where moisture is sufficient to maintain the plant's viability. Along streambanks and on floodplains where the water table is near the ground surface for a large part of the year, cottonwoods, willows, and water birch can occur (Brayshaw 1965).

PRESENT USES

Presently, the Short Grass Ecoregion is utilized for cattle production on native pasture, and crop production. Sugarbeets, alfalfa, and vegetable crops are important products from irrigated land, although wheat, oats, and barley are important on both irrigated and unirrigated lands.

Ecoregion 2 – Mixed Grass

The Mixed Grass Ecoregion is about two-thirds the size of the Short Grass Ecoregion (Table 1; Figure 4). Four separate areas comprise this ecoregion with the main unit located west and north of the Short Grass Ecoregion. The three remaining units are associated with land which is elevated above Ecoregion 1: the Cypress Hills (Alberta/Saskatchewan), the Sweetgrass Hills (Alberta/Montana), and an area near Oyen (Map 1).

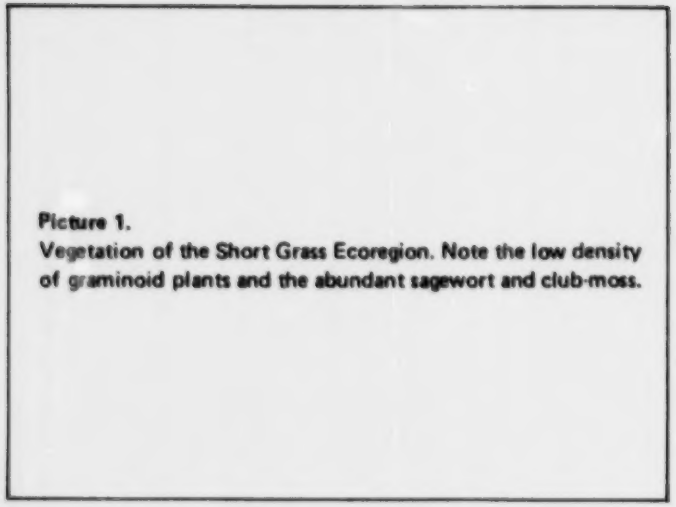
The boundary between the Short Grass and Mixed Grass Ecoregions is based primarily on the soil boundary separating the Brown and Dark Brown Chernozems. The western boundary of this Ecoregion corresponds to the Black/Dark Brown Chernozem soil boundary (Wyatt, Bowser and Odynsky 1939; Wyatt *et al.* 1943; Bowser, Peters, and Newton 1951; Peters and Bowser 1960a; Kocaoglu 1977)[9] while the northern limit occurs where aspen begins to form a significant component of the vegetation. Soil boundaries were used due to the disturbance of native vegetation.

Climatically, this area has a large range between summer and winter temperatures, although smaller than the range in the Short Grass Ecoregion (Table 2). Precipitation is moderate relative to other parts of the province, but higher

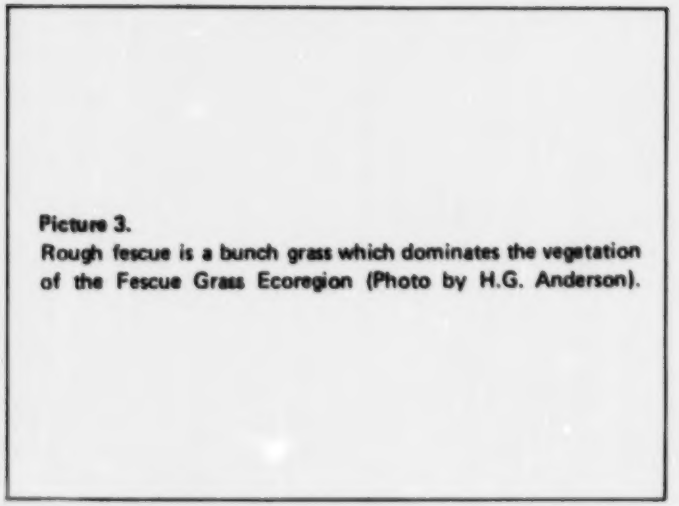
[7] See Appendix II for botanical names, nomenclature follows Moss (1959).

[8] Soils classification follows Canada Soil Survey Committee (1978).

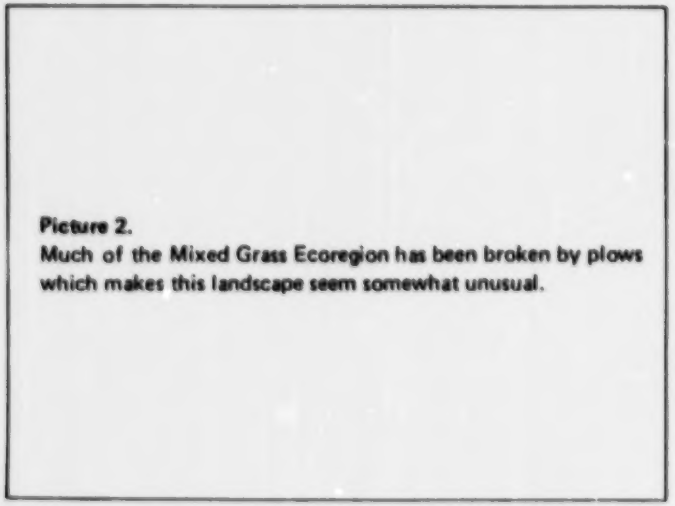
[9] Boundaries of older reports were modified on advice from W.W. Pettipiece, Agriculture Canada – Soil Survey – Edmonton.



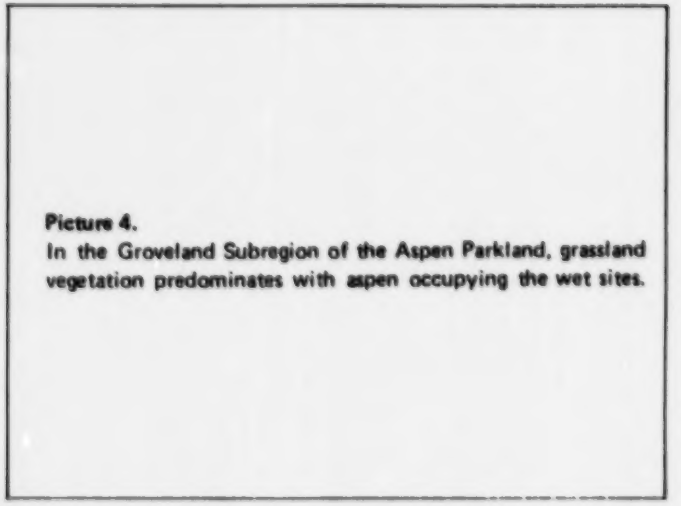
Picture 1.
Vegetation of the Short Grass Ecoregion. Note the low density of graminoid plants and the abundant sagewort and club-moss.



Picture 3.
Rough fescue is a bunch grass which dominates the vegetation of the Fescue Grass Ecoregion (Photo by H.G. Anderson).



Picture 2.
Much of the Mixed Grass Ecoregion has been broken by plows which makes this landscape seem somewhat unusual.



Picture 4.
In the Groveland Subregion of the Aspen Parkland, grassland vegetation predominates with aspen occupying the wet sites.

Figure 4
Location of Mixed Grass Ecoregion.

than in Ecoregion 1. This increased precipitation is due to a closer proximity to central Alberta storm tracks in the summer and increased elevation to the west which increases upslope precipitation during easterly flow. The bulk of precipitation occurs during the summer months (June maximum), which is typical of continental climates. Three stations which express the modal climatic conditions of this ecoregion are Craigmyle, Gleichen, and Lethbridge.

CLIMATIC CONDITIONS

All long-term climatic stations in the Mixed Grass Ecoregion receive between 200 and 290 mm of precipitation during the May to September period (Table 2). Nearly 80% of these stations receive more than 230 mm of precipitation which serves as the boundary between the Short Grass and Mixed Grass Ecoregions. The remaining 20% are located in valleys (e.g. Drumheller) and therefore receive less precipitation than the surroundings (Figure 2). The mean summer precipitation is approximately 50 mm higher than in Ecoregion 1. As with Ecoregion 1, this area has relatively low precipitation during July and August, with a maximum during June.

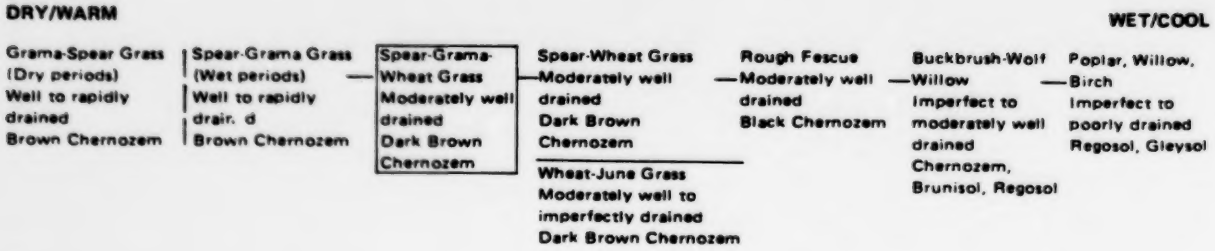
Although Ecoregion 1 and 2 can be distinguished by the quantity of summer precipitation, the Mixed Grass Ecoregion also has distinctive thermal characteristics. The mean and modal May to September temperatures are both lower than in the Short Grass Ecoregion (Table 2). The modal interval is 14.0 to 14.4°C in the Mixed Grass Ecoregion as compared to the mode of 14.5 to 14.9°C in the Short Grass Ecoregion. The decreased temperatures (range 13.5 - 15.0°C) are primarily the result of increased elevation to the west and latitude to the north. These lower temperatures result in a decreased accumulation of growing degree days. The area receives a mean of 1440 growing degree days which is 130 less than in the Short Grass Ecoregion. The freeze free period is similar in both the Short Grass and Mixed Grass Ecoregions.

The lower summer temperatures of the Mixed Grass Ecoregion are important in decreasing potential evapotranspiration. In the Mixed Grass Ecoregion, the climatic moisture deficit ranges from 200 to 300 mm with a mean of 240 mm; 60 mm less than Ecoregion 1.

In comparison with the Short Grass, the Mixed Grass Ecoregion has similar winter temperatures, a deeper snow cover, and the snow remains on the ground somewhat longer; however, these differences are small. The Claresholm-Pincher Creek-Lethbridge area receives in excess of 30 chinook days per year. The northern portions of the ecoregion receive less than 10 chinook days on the average.

ECOLOGICAL CONDITIONS

The semiarid late summer conditions of this area promote the development of grassland vegetation (Picture 2). Communities dominated by spear grass with secondary quantities of grama grass and wheat grass form the vegetation which represents this ecological system (Figure 5). This vegetation occurs on loamy, moderately well drained, Dark Brown Chernozemic soils (Coupland 1950, 1961). In comparison, the modal conditions of the Short Grass Ecoregion are more xeric and the soils are less humified. Mixed Grass sites that are more xeric than the modal conditions have vegetation and soils more typical of the Short Grass Ecoregion (Figure 5). Moist sites are characterized by the increase of more mesic grasses such as spear and wheat grasses, and fescue. Shrubs and trees occur on sites where moisture is locally available throughout most of the growing season. The forb component is similar to the Short Grass


DRY/WARM
WET/COOL
Grama-Spear Grass (Dry periods) Well to rapidly drained Brown Chernozem
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Wheat-June Grass Moderately well to imperfectly drained Dark Brown Chernozem
Rough Fescue Moderately well drained Black Chernozem
Buckbrush-Wolf Willow Imperfect to moderately well drained Chernozem, Brunisol, Regosol
Poplar, Willow, Birch Imperfect to poorly drained Regosol, Gleysol

Figure 5.
Mixed Grass Ecoregion - Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box. (Interpreted from Coupland 1950, 1952, 1961).

Ecoregion with sagewort and moss phlox amongst the more common plants (Coupland 1950), although they are usually less abundant than the graminoid cover.

As a result of decreased evapotranspiration and increased precipitation, more moisture is available for plant growth. Biomass on modal sites in good range condition is estimated at 475 kg/ha (Wroe *et al.* 1979). This is approximately 25% higher than in the Short Grass Ecoregion.

PRESENT USES

Irrigation and dry land farming are the major uses of the Mixed Grass Ecoregion. Small grain is the most common crop produced. Cattle grazing occurs where irrigation water is not available or the topography is unsuitable for tilled cropping.

Ecoregion 3 – Fescue Grass

The Fescue Grass Ecoregion lies west of the Mixed Grass Ecoregion in the south-central portion of the province (Figure 6). In total this area covers approximately 14,400 km^2 which makes it the smallest grassland ecoregion in Alberta (Table 1). This grassland area occurs on both plains and foothills topography. Boundaries for this ecoregion are based on the Black/Dark Brown Chernozem soil boundary and the eastern extent of aspen. The aspen boundary usually begins where aspen exceeds 15% cover. Black Chernozems are the common soils of this ecoregion.

The two previously discussed ecoregions were examples of Prairie climates in their more classic form. Although the Fescue Grass Ecoregion is a grassland, the region does not have a typical Prairie climate. This is due to two related factors: increased elevation and proximity to the Rocky Mountains. This results in decreased summer temperatures and increased winter temperatures relative to Ecoregions 1 and 2. The increased elevation and closeness to storm tracks through southwestern Alberta increases precipitation during all months, with much higher winter and early spring precipitation than the Short and Mixed Grass Ecoregions. These

Figure 6
Location of Fescue Grass Ecoregion.

precipitation and temperature characteristics are more typical of Cordilleran than Prairie climates. Acme and Cowley are two recording stations which display typical summer precipitation conditions. Mean summer temperatures within the ecoregion appear to have a bimodal distribution. The westernmost stations such as Cowley, Carway, and High River have a mean temperature more than 1°C cooler than Acme and Cardston which are located at lower elevations and in the eastern portion of the ecoregion.

CLIMATIC CONDITIONS

The mean annual precipitation in the Fescue Grassland is 520 mm, but it ranges from 370 mm at Trochu-Wimborne to 870 mm at Waterton River Cabin. The Waterton River Cabin recording station is anomalous in that its yearly precipitation is more typical of the Subalpine Ecoregion with more than 65% falling during winter. The site is located near the Subalpine boundary and coarse soils, strong winds, and warm temperatures counteract the effects of high winter precipitation.

May to September precipitation in the Fescue Grass Ecoregion ranges from 230 to 370 mm with a mean of 290 mm. This is approximately 30 mm greater than in the Mixed Grass. As with Ecoregions 1 and 2, June is the wettest month (ca. 100 mm) with July and August each receiving about 50% of June. The Waterton area is once again anomalous as its maximum occurs in April or May (Powell 1977). In addition to the increased quantity of precipitation, the number of days with precipitation is also greater than other grassland ecoregions (Table 2).

Although the Fescue Grass Ecoregion is wetter than the Mixed Grass, the feature that distinguishes the two appears to be the May to September mean temperatures. The mean summer temperature (12.5°C) is 2.0°C lower than in the Mixed Grass Ecoregion. Mean May to September temperatures range from 11.0 to 13.5°C in the Fescue Grass Ecoregion while the Mixed Grass ranged from 13.5 to 15.0°C. The former has a greater range of freeze free periods (i.e. 25 to 110 days) and shorter mean freeze free period than the previously described ecoregions. For example, the Lundbreck climate station which was located north of the village on the lower slopes of the Porcupine Hills had a long term mean freeze free period of only 25 days. The lower summer temperatures are also reflected in a decreased accumulation of growing degree days. The Fescue Grass Ecoregion receives an average of 230 growing degree days less than the Mixed Grass Ecoregion. The lowest number of accumulated growing degree days occurs at Lundbreck with 950 which shows the harsh conditions of frost prone areas of foothills portions of this ecoregion.

The climatic moisture deficit is another factor which can be used to distinguish the Fescue Grass Ecoregion from the Mixed Grass. In the latter, the May to September moisture deficit ranges from 200 to 300 mm, whereas in the Fescue Ecoregion it ranges from 100 to 200 mm. The mean is 170 mm which shows that more moisture is available in the Fescue Ecoregion than in Ecoregions 1 and 2.

Winter temperatures in this ecoregion are warmer than the other two grassland ecoregions (Table 2). In fact the Fescue Grass and Montane (5) Ecoregions have the warmest December to February temperatures in the province due largely to the influence of chinooks. Although mean October to April precipitation is noticeably higher, snow depth and cover are comparable to the two previous ecoregions.

ECOLOGICAL CONDITIONS

The Fescue Grass Ecoregion lies between the Aspen Parkland (Ecoregion 4) and the drier Mixed Grass Ecoregion. The Aspen Parkland and Fescue Grassland receive nearly equal amounts of summer precipitation; however, precipitation occurs early in the summer within the Fescue Grass Ecoregion which produces a significant late summer moisture deficit. These subhumid conditions promote the development of graminoid vegetation. Rough fescue dominates the native vegetation with secondary quantities of Parry oat grass (Moss and Campbell 1947; Moss 1944, 1955; Looman 1969). June grass, chickweed, sticky geranium, lupines, yellow bean, sage, yarrow, bedstraw, and fleabanes are amongst the more common herbs found in the Fescue Grassland (Picture 3).

Figure 7 illustrates some of the common ecosystems found in the Fescue Grass Ecoregion, and their ecological relationships and conditions. Shrub communities become increasingly important as moisture increases, although such communities occupy less than 5% of the area. Shrub communities usually occur in suitable niches such as on steep north-facing slopes, in ravines, and seepage sites. These niches have more available moisture as a result of delayed snow melting, reduced evaporation, and/or seeping groundwater. Dry sites such as steep south aspects where solar radiation input is high, or coarse textured soils (glacio-fluvial or aeolian deposits) are areas which promote the development of xeric plant communities (Figure 7).

Black Chernozems are the typical soils of the Fescue Grass Ecoregion. They have been referred to as "shallow" (Ah less than 30 cm) Black Chernozems (Wyatt, Bowser, and Odynsky 1939; Moss and Campbell 1947) as opposed to "deep" Black Chernozems which are more characteristic of the Aspen Parkland. Although shallower and less well developed than Aspen Parkland soils, they have a higher organic content than Ecoregions 1 and 2, and are thus more productive. The higher organic content results from increased humification of surface soil horizons.

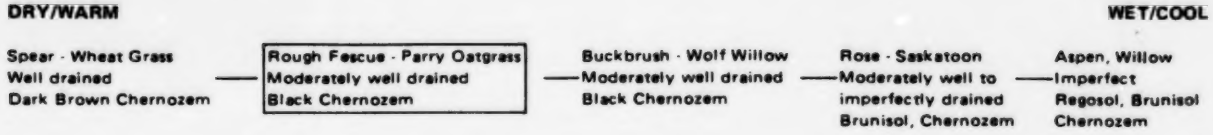


Figure 7.
Fescue Grass Ecoregion - Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

PRESENT USES

Land suitable for tilled cropping is used for grain production while grazing dominates the native grasslands. Native forage production is approximately twice that of the Mixed Grass Ecoregion (Lodge *et al*. 1971).

CLIMATIC CONDITIONS

Mean yearly precipitation in the Aspen Parkland is 450 mm, which is 70 mm less than the Fescue Grassland and 50 mm more than the Mixed Grass Ecoregion. Mean annual precipitation ranges from 390 mm at Camrose to 710 mm at Mountain View - Birdseye (SW Alberta). A zone of high precipitation is restricted to the foothills and occupies a small portion of this ecoregion. It should be

Ecoregion 4 — Aspen Parkland

The Aspen Parkland is the second largest ecoregion in Alberta, covering approximately 73 500 km^2 or 11.1% of the province. The main Aspen Parkland area is located north of the Mixed Grass and west of the Fescue Grass Ecoregions. Several small outliers of Aspen Parkland occur along the Rocky Mountains, in the Cypress Hills (Breitung 1954, Newsome and Dix 1968), and near Grande Prairie (Figure 8). The Aspen Parkland abuts several ecoregions on its western and northern boundaries. Subdued topography occurs throughout the area, except in the foothills zone of south-western Alberta.

Aspen Parkland was delineated on the basis of co-existent Chernozemic soils (Black and Dark Brown) and aspen/grassland vegetation. Soil survey reports (Wyatt *et al*. 1938, 1943, 1944; Bowser *et al*. 1947; Bowser, Peters and Newton 1951; Peters and Bowser 1960a, 1960b; Lindsay *et al*. 1968; Kjearsgaard 1972; Kocaoglu 1975), ecological survey reports (Bird and Hong 1975; Anderson 1978, 1979; Strong 1979), and aerial photographs were the principle reference materials employed to delineate Ecoregion 4.

Components of Alberta's Boreal and Prairie climates interact to create the regional climate of the Aspen Parkland. The mid-Alberta storm track also has a significant influence on the climate of most of this ecoregion which makes it different from Ecoregions 1, 2, or 3. The major difference from grassland ecoregions is that precipitation in the Aspen Parkland is more evenly distributed throughout mid-summer, rather than concentrated in June. Once again, temperatures show a continental influence as they have large yearly and daily ranges (Table 2). Climate stations which display the modal climatic conditions are Brownfield, Viking, and Stettler.

Figure 8.
Location of Aspen Parkland Ecoregion.

noted that more than 40% of the precipitation which falls in this restricted area occurs during winter.

Mean May to September precipitation ranges from 250 mm at Grande Prairie to 400 mm at Turner Valley with a mean of 300 mm (Table 2). The factor which distinguishes the Aspen Parkland from grassland ecoregions is not summer precipitation totals, but rather its distribution. As can be seen from Figure 9, the Aspen Parkland receives considerably more precipitation during July and August than the Mixed Grass or Fescue Grass Ecoregions. This increase in moisture during the middle and end of the growing season reduces moisture stress on vegetation, and is likely critical to survival of aspen.

Although the range of mean May to September temperatures in the Aspen Parkland is greater than in the Fescue Grassland, the mean values for the two ecoregions are similar. The cooler sites in each ecoregion are associated with the Rocky Mountain foothills of southwest Alberta. The mean May to September temperature in the Aspen Parkland is lower than the Mixed Grass Ecoregion.

The freeze free period throughout much of the Aspen Parkland exceeds 90 days which is adequate for cereal crops grown in the province. However, sites such as Pekisko, which occur in the foothills, have a mean freeze free period less than 50 days. Mean May to September accumulated growing degree days in the Aspen Parkland is approximately 1260 which is higher than in the Fescue Grass Ecoregion but much lower than the Mixed Grassland. Portions of the Aspen Parkland in the Rocky Mountain foothills are considerably cooler than the remainder of the ecoregion so that accumulated growing degree days may drop well below 900.

The mean December to February temperatures in the Aspen Parkland are lower than in the Fescue and Mixed Grass Ecoregions. That portion of the Aspen Parkland south of Carstairs west of the Fescue Grassland has winter temperatures more similar to those of the Fescue Grassland, and also receives more chinooks than the remainder of the ecoregion. Most of the Aspen Parkland receives an average of fewer than 15 chinooks per winter. Lower winter temperatures and decreased chinook activity prolong snow cover and increase snow depth as compared to the grassland ecoregions.

ECOLOGICAL CONDITIONS

The Aspen Parkland is climatically and ecologically a transition zone between boreal forests and grassland environments. Increased moisture availability in the late summer and the distinct vegetation physiognomic structure distinguishes this area from adjoining ecoregions. This ecoregion was one of the first ecological areas recognized in Alberta,

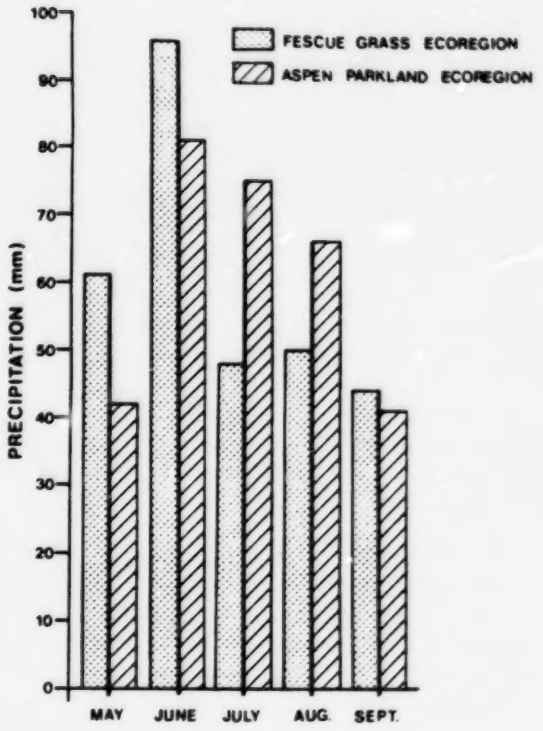


Figure 9.
Mean Monthly Precipitation from May to September in the Fescue Grass and Aspen Parkland Ecoregions.

and has been the subject of numerous studies. Amongst the more notable researchers were Bird (1930), Moss (1932), Halliday (1937) and Dormaar and Lutwick (1966).

The Aspen Parkland can be subdivided into three portions: the Groveland Subregion, the Aspen Subregion, and the Willow Subregion.[10] The Groveland Subregion is a tension zone between the Fescue and Mixed Grass Ecoregions, and the Aspen Subregion. The Cypress Hills unit falls into the Groveland Subregion. Clones of aspen dot the rough fescue grassland on sites where moisture is adequate to sustain tree growth throughout the growing season (Picture 4). Such sites are north-facing slopes, seepage areas, and creek banks. In total, this area has approximately 15% aspen cover with fescue grassland and shrub communities comprising the remaining cover. The grasslands are dominated under natural conditions by rough fescue, Idaho fescue, june grass, spear grass, prairie smoke, sticky geranium, and bedstraw.

[10] The term subregion is used to describe a subdivision of the ecoregion and is not intended to be a classification unit.

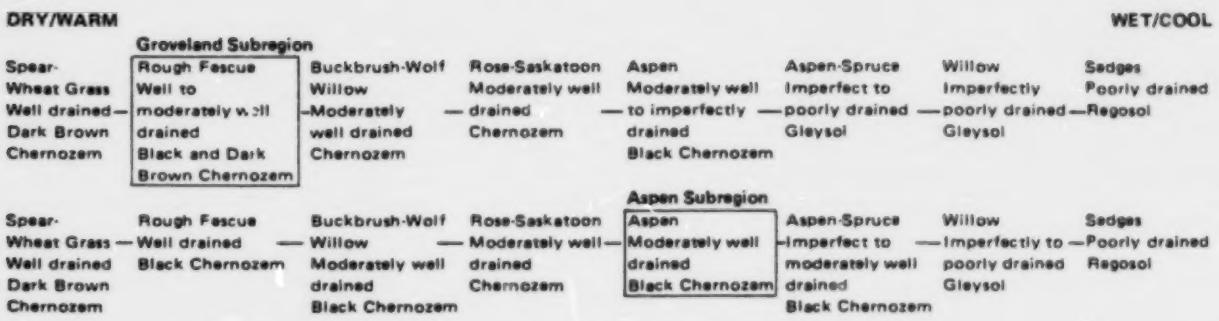

DRY/WARM
WET/COOL
Groveland Subregion
Spear-Wheat Grass Well drained Dark Brown Chernozem
Rough Fescue Well to moderately well drained Black and Dark Brown Chernozem
Buckbrush-Wolf Willow Moderately well drained Chernozem
Rose-Saskatoon Moderately well drained Chernozem
Aspen Moderately well to imperfectly drained Black Chernozem
Aspen-Spruce Imperfect to poorly drained Gleysol
Willow Imperfectly poorly drained Gleysol
Sedges Poorly drained Regosol
Aspen Subregion
Spear-Wheat Grass Well drained Dark Brown Chernozem
Rough Fescue Well drained Black Chernozem
Buckbrush-Wolf Willow Moderately well drained Black Chernozem
Rose-Saskatoon Moderately well drained Chernozem
Aspen Moderately well drained Black Chernozem
Aspen-Spruce Imperfect to moderately well drained Black Chernozem
Willow Imperfectly to poorly drained Gleysol
Sedges Poorly drained Regosol

Figure 10.
Aspen Parkland Ecoregion. – Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

Grassland represents the drier portion of Groveland (Figure 10). Dark Brown and Black Chernozems are typical soils of this area.

Shrub communities are a conspicuous part of the Groveland Subregion. Shrub communities are frequently found on north-facing slopes, ravines, and localities that accumulate snow. These sites provide moisture much later in the summer than is available in the surrounding areas. Saskatoon, wild rose, buckbrush, snowberry, and silverberry are typical species of these communities.

The Aspen Subregion is dominated by clones of aspen, although patches of grassland occur (Moss 1932). This subregion occurs adjacent to mesic ecoregions on its western and northern boundaries and represents the more mesic subregion of the Aspen Parkland (Figure 10). The increased soil moisture and humidity conditions beneath the aspen stands favor the development of a lush and diverse understory. Veiny meadow rue, bedstraw, wild strawberry, wild roses, larkspur, violets, saskatoon, willow, and fireweed are common understory species. Soils are commonly "deep" Black Chernozems although Dark Gray Chernozems occur where prolonged aspen occupation has eluviated the soil. Although aspen is dominant at present, these soils formed beneath grassland vegetation.

Willows form a unique subregion that occurs in the southwestern portion of the Aspen Parkland. This band extends from the Porcupine Hills area (Strong 1979) to north of Calgary along the eastern boundary of the Aspen Parkland. Little is known about this area, although it was recognized in the early 1930's (Moss 1932). Ecologically, fescue grassland occupies drier sites, while stands of willows occur on moderately to imperfectly drained sites. Black Chernozem soils are dominant.

Prior to European settlement of the Aspen Parkland much of the area was probably dominated by grassland vegetation (Strong 1977). However, settlement reduced the frequency of fire throughout the area and allowed the southward and eastward advance of aspen into the grasslands (Bird 1961; Nelson and England 1971; Bailey and Wroe 1974; Strong 1977).

PRESENT USES

Presently, the Aspen Parkland represents one of the most productive agricultural zones in Alberta. Barley, wheat, rapeseed, and oats are the most commonly tilled crops. Beef cattle grazing occurs in the foothills and on rough topography.

Ecoregion 5 – Montane

On a provincial scale, the Montane Ecoregion is restricted to the foothills and major valleys of the Rocky Mountains. The main representation of the Montane Ecoregion in Canada lies in British Columbia with that portion in Alberta representing the eastern extremity. The main occurrences are in the vicinity of the Porcupine Hills, Crowsnest Pass, and foothills north of Waterton Lakes National Park (Figure 11). The Bow, Saskatchewan, and Athabasca River valleys also contain Montane vegetation. In total the Montane Ecoregion composes only 0.5% of the province or approximately 3838 km^2. Elevationally, the Montane occurs below the Subalpine (Ecoregion 6) and above the Fescue Grassland and Aspen Parkland Ecoregions.

The Montane is distinguished from other ecoregions on the occurrence of Douglas fir and/or limber pine. Although these are diagnostic species, white (x Engelmann) spruce and lodgepole pine are also important arboreal components (Lopoukine 1970). Distribution patterns of tree species for all ecoregions are presented in Table 3.

Figure 11.
Location of Montane Ecoregion.

The modal climate of the Montane Ecoregion in Canada occurs in British Columbia. Alberta's Montane Ecoregion is at the cooler end of the Montane climatic spectrum. In Alberta the Montane Ecoregion displays both Cordilleran and Prairie climatic influences with eastern portions and lower elevations more continental in character. The salient feature of this ecoregion is its association with major east-west mountain valleys. The valleys are warm during winter as they channel warm modified Pacific air into Alberta and often escape outbreaks of cold Arctic air which invade Alberta from the north. The grassland and Aspen Parkland ecoregions have precipitation maxima during summer while Ecoregion 5 has secondary precipitation maxima in winter and a primary maximum in summer. The increased winter precipitation is a characteristic of Cordilleran climates. Coleman, Kananaskis, Castle Ranger Station, and Porcupine Lookout display climatic regimes most typical of the Montane Ecoregion of Alberta.

CLIMATIC CONDITIONS

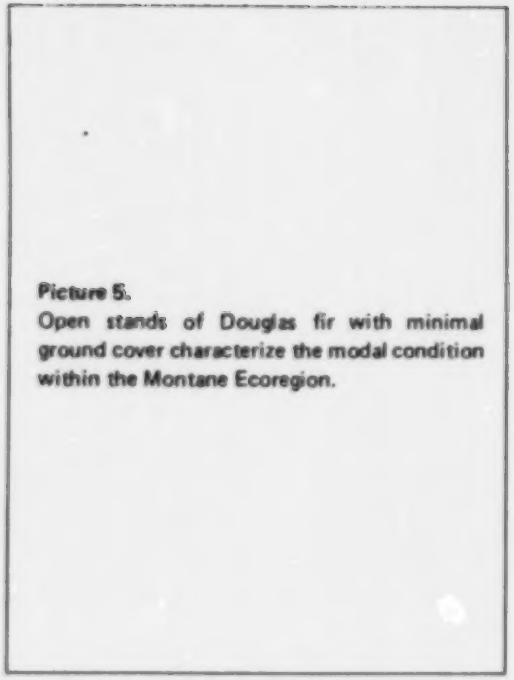
Yearly precipitation totals from recording stations in Alberta's Montane Ecoregion range from 280 mm to 810 mm with a mean of 560 mm. Precipitation totals below 400 mm are associated with the Kootenay Plains and the Canmore Corridor area. They have a mean annual precipitation total similar to the grassland ecoregions. In the Montane the yearly mean is about 25% higher than that of the Aspen Parkland with the mean summer precipitation total comparable to that of the Parkland Ecoregion (Table 2). Winter precipitation accounts for this difference. Maximum winter precipitation occurs in December or January. In the Aspen Parkland a mean of 33% of the yearly total precipitation occurs from October to April, but in the Montane 40 to 70% occurs during this period. The lowest winter precipitation sums occur at Jasper and in the Kootenay Plains while the wettest areas are found south of the Crowsnest Valley in the Castle River area. Summer precipitation shows a distinct maximum during June in all stations except Jasper. Most of the ecoregion has low precipitation during July and August.

The mean May to September temperature is approximately 1 to 1.5°C lower in the Montane than in the Fescue Grass and Parkland Ecoregions (Table 2). The most significant climatic characteristic that distinguishes the Montane from other ecoregions in Alberta is winter temperatures. The warmest mean December to February temperature (-7.5°C) occurs in the Montane. Chinook activity and the reduced influence of cold Arctic air contribute to these warmer conditions. Snow cover lasts longer and is deeper than in the previously discussed ecoregions. Topography plays an important role as snow is removed from west-facing slopes and deposited on east-facing slopes by the dominant westerly winds.

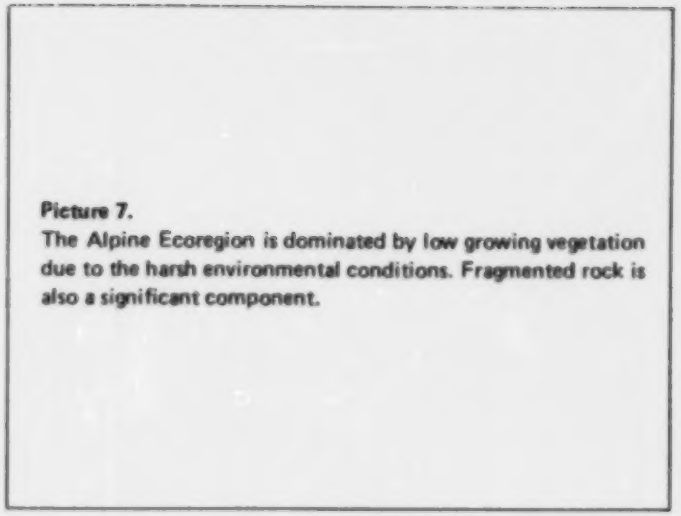
The accumulation of growing degree days and the freeze free period during the summer are much lower than in the Fescue Grassland and Aspen Parkland. The climatic moisture deficit shows a range from -240 to -40 with a mean of -160 mm. This is very similar to means of Ecoregions 3 and 4.

ECOLOGICAL CONDITIONS

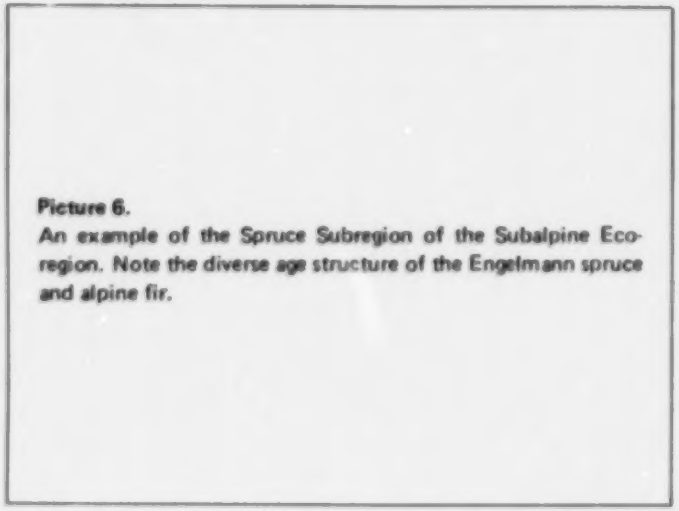
Ecological conditions are highly variable in the Montane Ecoregion. Much of this variation is probably the result of its complex topography, small size, and marginal adaption to Alberta's climate. Douglas fir is considered the diagnostic species and forms the representative vegetation for the region, although it does not rigidly fit the concept of modal vegetation (Picture 5). Figure 12 represents some of the common ecosystems that occur in the Montane Ecoregion.



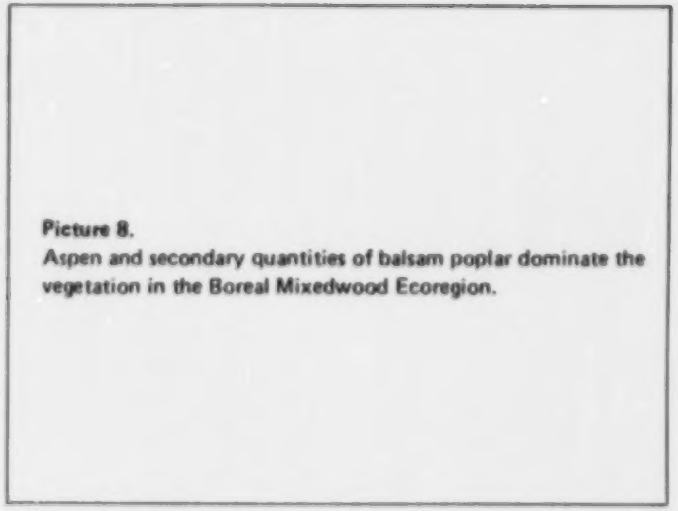
Picture 5.
Open stands of Douglas fir with minimal ground cover characterize the modal condition within the Montane Ecoregion.



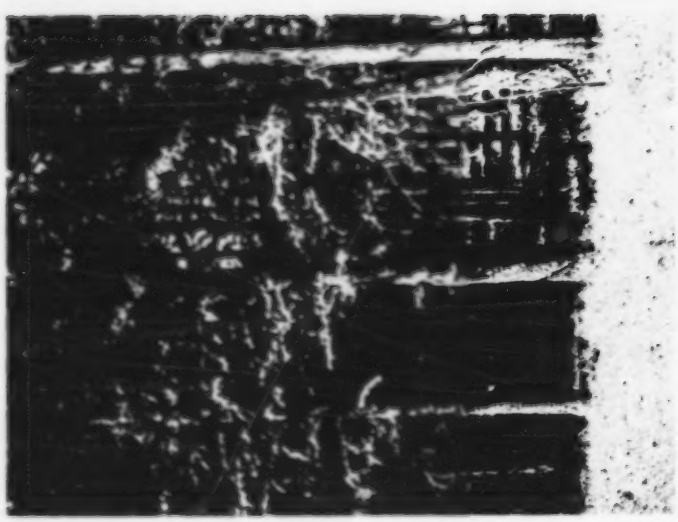
Picture 7.
The Alpine Ecoregion is dominated by low growing vegetation due to the harsh environmental conditions. Fragmented rock is also a significant component.



Picture 6.
An example of the Spruce Subregion of the Subalpine Ecoregion. Note the diverse age structure of the Engelmann spruce and alpine fir.



Picture 8.
Aspen and secondary quantities of balsam poplar dominate the vegetation in the Boreal Mixedwood Ecoregion.



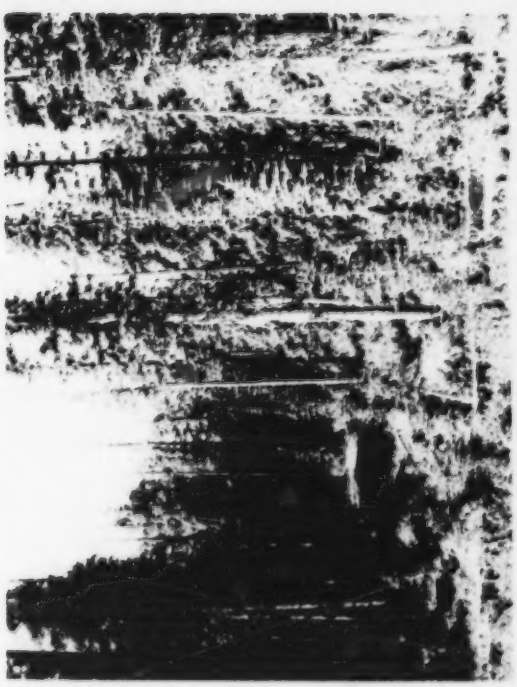


Table 3
TREE SPECIES AND RELATIVE ABUNDANCE BY ECOREGION

Ecoregion	No.	Aspen	Balsam Poplar	Cottonwoods	Black Spruce	Engelmann Spruce	White Spruce	Jack Pine	Limber Pine	Lodgepole Pine	Whitebark Pine	Alpine Fir	Balsam Fir	Douglas Fir	Alpine Larch	Tamarack	Paper Birch
Short Grass	1	–	–	R	–	–	–	–	–	–	–	–	–	–	–	–	–
Mixed Grass	2	–	–	O	–	–	–	–	–	–	–	–	–	–	–	–	–
Fescue	3	O	R	O	–	–	–	–	–	–	–	–	–	–	–	–	–
Aspen Parkland	4	D	O	O	R	–	O	–	–	–	–	–	–	–	–	–	–
Montane	5	C	O	O	–	R	C	–	O	C	–	–	–	C	–	–	–
Subalpine	6	O	O	–	R	C-D	R	–	R	D	O	O-C	–	R	O	–	–
Alpine	7	–	–	–	–	O	–	–	R	–	–	R	–	–	R	–	–
Boreal Mixedwood	8	D	C	–	C	–	C	C	–	R	–	–	R	–	–	O	O
Boreal Foothills	9	D	C	–	C	–	C	R	–	C	–	R	R	–	–	O	O
Boreal Uplands	10	R	O	–	C	O	C	–	–	D	–	O	–	–	–	R	R
Boreal Northlands	11	D	C	–	C	–	D	C	–	R	R	R	R	–	–	O	O-R
Boreal Subarctic	12	R	R	–	C	–	R	R	–	R	–	–	–	–	–	–	–

D Dominant, a prominent species in terms of cover and influence on the environment
C Common, an abundant species
O Occasional, a species that occurs frequently but with little influence on the environment
R Rare, occurs infrequently
– Does not occur

Open stands of Douglas fir on shallow, moderately well drained, medium textured Eutric Brunisols typify the common vegetation community. In cooler areas Douglas fir occupies sites which have coarse textured, well drained soils, and/or steep south aspects where solar insolation is increased. Winter temperatures may play an important role in determining the distribution of Douglas fir. Treidl (1978) suggests that this species is associated with mean January temperatures above -7.0°C. Such temperatures do not exist in the province; however, the Montane has the warmest January temperatures (mean of -10.0°C) of any ecoregion in Alberta.

Microclimatically and edaphically dry sites are characterized by grassland vegetation. These grasslands are usually associated with steep south-facing slopes or coarse textured soils. Grassland species composition varies with the geographical location. In the southern portion of the Montane Ecoregion, fescue and oat grass form the principle grassland species, while in the northern portions reed, rye, and june grass become dominant (Stringer and La Roi 1970; Stringer 1973).

Limber pine, a diagnostic species of the Montane Ecoregion, occurs on sandstone outcrops. These outcrops form steep ridges that are rapidly drained and produce large moisture deficits.

Moist and cool sites, such as north aspects, are occupied by aspen and lodgepole pine with white spruce and Douglas fir common invaders (Figure 12). Increased moisture availability for plant growth results from reduced evapotranspiration. In the cooler portions of the ecoregion this vegetation type occurs on southerly aspects. Soils reflect the increased moisture conditions as they are somewhat more differentiated than those beneath Douglas fir, although they are commonly Eutric Brunisols.

PRESENT USES

The majority of the Montane Ecoregion landscape consists of steep and rough topography. As a result activities such as recreation and domestic grazing are common. This area may form an important winter habitat area for large ungulates (Strong and Vriend 1980).

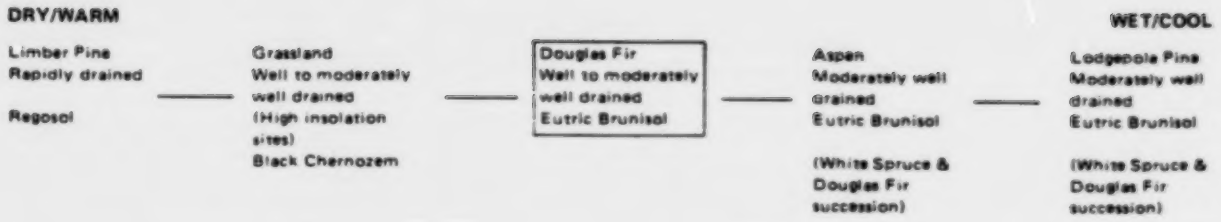


Figure 12.
Montane Ecoregion – Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

Ecoregion 6 – Subalpine

The Subalpine Ecoregion is an altitudinal vegetation zone with the upper boundary formed by the Alpine Ecoregion and the lower boundary abutting the Montane, Aspen Parkland, and the Boreal Uplands Ecoregions (Table 1; Map 1). It stretches northward along the Rocky Mountains in Alberta from the Montana border to a point west of Grande Cache (Figure 13). The ecoregion also occurs in British Columbia and the Rocky Mountains area of the United States (Krajina 1965; Rowe 1972; Ross and Hunter 1976). In Alberta the Subalpine occurs from 1520 to 2135 m (5000 - 7000 ft.) south of the Bow River (Anderson 1978, 1979; Strong 1979), 1620 to 2135 m (5300 - 7000 ft.) north of the Bow River, and 1490 to 1975 m (4900 - 6500 ft.) in the vicinity of Grande Cache. The reason for this rise in the lower boundary north of the Bow River is not clear, but it may be the result of Engelmann and white-black spruce competition. The occurrence of Engelmann (x white) spruce is the criteria used to differentiate the Subalpine Ecoregion from other ecoregions (Table 3).

Coniferous forest dominates the Subalpine landscape with deciduous species such as aspen only occurring on warm sites (Picture 6). Climatic and geomorphic factors do not promote the development of deep well defined soil profiles. Brunisolic soils are the most abundant soils in Ecoregion 6.

The Subalpine Ecoregion has a Cordilleran climate characterized by snowy cold winters and showery cool summers. Increased winter precipitation, relative to ecoregions previously discussed, is due to the increased influence of Pacific air masses which are warmer and more moist than Arctic air masses which are dominant further to the east during winter. The area of the province occupied by Ecoregion 6 also receives a high proportion of its annual precipitation during upslope or easterly flow (Reinelt 1970).

The interior continental location of the Subalpine results in a large range of both yearly and daily temperatures, although these ranges are not as great as can be found in the grassland ecoregions. This reflects more of a maritime influence. Summer temperatures decrease with increased elevation while winter temperatures tend to increase. The climate of this ecoregion is highly variable and data are sparse, but Lake Louise and Livingstone Gap Ranger Station display summer climatic regimes which are typical of the Subalpine Ecoregion.

Figure 13.
Location of Subalpine Ecoregion.

CLIMATIC CONDITIONS

Mean annual precipitation in the Subalpine Ecoregion is 720 mm but there is a wide range from 350 to 1230 mm. There are some indications that the extreme southwest corner of this ecoregion receives 1400 mm or more (Powell 1977). The driest portion of the ecoregion is found in the Cline-Upper North Saskatchewan River valleys. The mean May to September precipitation of 320 mm is only slightly greater than in the Aspen Parkland and Montane, whereas the mean October to April precipitation in the Subalpine is 100 mm greater than the Montane and 240 mm greater than the Aspen Parkland. In the Subalpine 40 to 68%, or an average of 49% of the yearly precipitation occurs during the October to April period. Not only are precipitation totals greater, but precipitation events (Table 2) are much more frequent.

The mean May to September temperature in the Subalpine is 9.5°C which is 2.0°C cooler than the Montane. Elevational effects on temperatures in this ecoregion are important. During summer, daytime temperatures in Subalpine valleys are warmer than valley slopes. This trend is often reversed at night, however, as cold air drains into the valley bottom making it much cooler than the valley slopes.

Below freezing temperatures in the Subalpine are common during all months with the lowest frequency during July and August. From May to September an average greater than 1 day in 3 has subfreezing temperatures. A map prepared by Powell and MacIver (1977) and unpublished data supplied by J.M. Powell suggest this ecoregion has from 15 to 35 days during May to September with minima -2.2°C or below. This is much higher than found in ecoregions discussed to this point. Data from Lake Louise and Mount Eisenhower show a mean freeze free period of only 15 days.

Cool conditions are also reflected in the low accumulation of growing degree days. The range is 710 to 930. As the maximum number of growing degree days found in the Subalpine corresponds to the minimum in the Montane, summer coolness and subfreezing temperatures appear to be important in delineating the Subalpine from the Montane and Aspen Parkland.

A mean climatic moisture deficit of -110 mm for this ecoregion may be misleading as temperature data in this ecoregion are limited. Much of this ecoregion actually has a large climatic moisture surplus.

The mean December to February temperatures in the Subalpine is -9.0°C which is slightly cooler than the Montane and Fescue Grassland but much warmer than Ecoregions 1, 2, and 4. For the most part, chinooks are infrequent in the Subalpine but they are most important in the portions associated with the major mountain valleys. The relatively warm winters in the Subalpine are due to the high elevations of the ecoregion. Temperatures during winter tend to increase with increased altitude under certain conditions as the Subalpine escapes the severe cold of outbreaks of shallow Arctic air. Also, as mentioned earlier, warm Pacific air masses influence this ecoregion during winter. The mean January temperature is -11.5°C with a range of -10.0 to -13.0°C. Mean snow depth and period of snow cover are greater in the Subalpine than in any of the ecoregions previously discussed. The mean snow depth in April ranges from 40 to 160 cm (Janz and Storr 1977) in the Banff and other National Parks but is much deeper in the Waterton area.

ECOLOGICAL CONDITIONS

The Subalpine Ecoregion can be dissected into three portions: the Pine, Spruce-Fir and Upper Subalpine Subregions. Although these subregions have not been widely recognized in Alberta, the United States Forest Service has formally identified these types of subregions in Montana (Pfister *et al.* 1977). Figure 14 illustrates the relationship between various vegetation types that occur in the Subalpine Ecoregion. The Upper Subalpine does not fit the scheme and was not included on Figure 14. This area may be more closely aligned with the Alpine (Ecoregion 7), although it has traditionally been associated with the Subalpine.

The Pine Subregion is a zone of lodgepole pine which shows little evidence of succession to Engelmann spruce and/or alpine fir in the first 100 or more years of stand growth. This zone occurs at the lowest elevations of the Subalpine Ecoregion. The Pine Subregion may be too xeric for "typical" spruce-fir succession. A further causal factor may be a lack of spruce seed caused by frequent fires. Until the overstory has produced a suitable moisture regime for spruce invasion the stands remain a monoculture. Soils of this area are shallow poorly developed Eutric Brunisols. Lodgepole pine stands and Eutric Brunisol soils develop on a variety of slopes and parent materials.

The Spruce-Fir Subregion is located altitudinally above the Pine Subregion. Forests of this area differ from the previous subregion by displaying evidence of spruce-fir succession in the early stages of stand development. Although lodgepole pine stands are common, the area is characterized by forests of co-dominant Engelmann spruce and alpine fir. Spruce is usually much more abundant. Moisture is more abundant in this subregion than in the Pine Subregion. This results in Eutric Brunisols which have a better profile differentiation and show distinct evidence of eluviation.

The Upper Subalpine Subregion is characterized by open canopied vegetation that occurs between the Spruce-

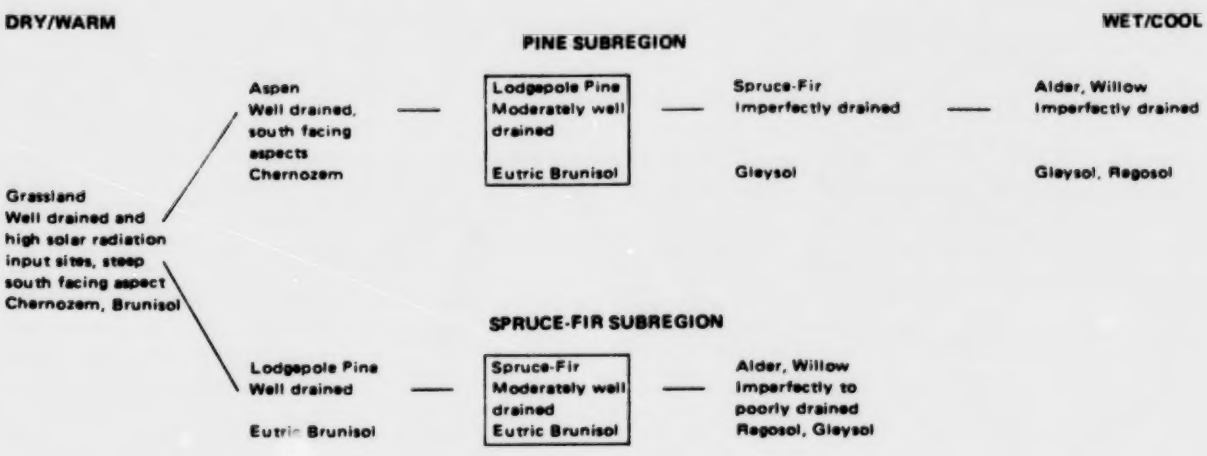


Figure 14.
Subalpine Ecoregion – Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

Fir Subregion and climatic forest-line of the upper elevational limit of continguous tree growth (Ogilvie 1976). Winds and moisture stress are probably among the most critical factors influencing the vegetation of this subregion. Dwarfed Engelmann spruce, alpine fir and whitebark pine, and open stands of alpine larch are typical species and growth forms of this zone. Plant growth is retarded in this zone due to the low temperatures, high wind, moisture stress, and the short growing season. Regosolic and weakly developed Brunisolic soils are common because of the severe ecological conditions.

Scattered throughout the Subalpine Ecoregion are grasslands. These grasslands typically occur on steep south facing slopes where solar insolation and evapotranspiration are very high. Fescue, spear, wild rye, and wheat grasses are the most common species. Soils with humified surface horizons are typical beneath these grassland ecosystems.

PRESENT USES

Watershed management and protection, forest production, National Parks, and recreation are amongst the land uses that can be observed in the Subalpine Ecoregion. The area is also important as habitat for wildlife species.

Ecoregion 7 – Alpine

The Alpine ecoregion occurs above climatic forest-line in the Rocky Mountains (Figure 15). It is situated above the Subalpine Ecoregion. Forest-line is defined as the zone where contiguous forest stops and isolated islands of trees begin (Ogilvie 1976). Elevationally, the Alpine occupies

Figure 15.
Location of Alpine Ecoregion.

terrain above 2135 m (7000 ft.) in the southern portions of its extent but declines to approximately 1980 m (6500 ft.) in the northern portions. Less than 3% of the province is composed of this ecosystem. Much of the Alpine Ecoregion occurs under the jurisdiction of Federal and Provincial Governments in the form of parks and wilderness areas. Vegetation types vary depending on substrate and protection from the harsh environment. Glaciers are non-vegetated while rock fields and fractured bedrock support scattered crustose lichens. Other vegetation types include low-growing shrub communities (evergreen and deciduous) and fescue grasslands with scattered krumholz whitebark pine. This extreme variability is due to many environmental factors amongst them are strong winds, moisture stress, insolation intensity, snow protection, and substrate. Soils are poorly developed due to the harsh alpine environment (Picture 7).

This ecoregion has a more severe Cordilleran climate than the Subalpine. The overriding climatic elements which characterize the Alpine are strong winds, long winters, and summer coolness. Below freezing temperatures are common even during the warmest months. Precipitation is high during all months with a tendency for greater precipitation during winter. Precipitation events are more common in this ecoregion than any other, but their intensity is lower. This is due to a decrease in available moisture with increasing altitude in the atmosphere. The most notable climatic factor of this ecoregion, other than its harshness, is its diversity. The Alpine is composed of surfaces with all aspects and a wide range of slope angles. As there is no overstory vegetation the surface displays a highly variable microclimate. During summer the climates of steep south-facing slopes differ markedly from north-facing slopes. During winter southwest to northwest-facing slopes may be completely snow free whereas east aspects or protected pockets may have snow cover several metres deep which may last well into summer, or even year round.

Because of the extreme spatial variability of the climate in this ecoregion, the identification of modal climate stations is difficult and perhaps misleading. In terms of data that are available, Hailstone and Kiska Lookouts display modal summer temperatures. Wilkinson Summit and Onion Lake display modal precipitation conditions.

CLIMATIC CONDITIONS

The range in Alpine mean annual precipitation is not as great as that in the Subalpine but the mean is very similar at 730 mm. This is the highest mean value of any ecoregion in the province. Precipitation in this ecoregion increases from north to south. The mean May to September precipitation is 360 mm which is 40 mm higher than in the Subalpine Ecoregion. The range in summer Alpine precipitation is 270 to 430 mm. The month of maximum precipitation during summer is June. Unfortunately, no data are available for the Alpine north of the Brazeau River and it is suspected that precipitation may be greatest in July within this portion of the Alpine. In the Alpine Ecoregion a mean of more than 50% of the total annual precipitation occurs during October to April. The mean precipitation for this period is 400 mm, which is very similar to the Subalpine. Although snowfall is high in the Alpine, snow cover distribution is highly variable.

From long term climate stations in the Alpine a mean summer temperature of 6.5°C was calculated with a range of 4.0 to 7.5°C. Low mean summer temperatures set the Alpine apart from all other ecoregions. The mean July temperatures in the Alpine are 10.0°C or lower, whereas in the Subalpine they are 12.0°C or warmer. The occurrence of freezing temperatures in the Alpine is spatially variable. Exposed south-facing slopes may have freeze free periods in excess of 25 days, but depressions and protected areas may be limited to freeze free periods of several days in length. Growing degree day accumulation above 5.0°C is very low in the Alpine. It is likely less than 500 degree days are accumulated, but this will depend on slope angle and orientation.

Unfortunately, data for the winter months in the Alpine are limited. Mean January temperatures are approximately -15.0°C. This ecoregion does not experience "chinooks" and temperatures rarely if ever go above 0°C during the December to February period. Snow depth can vary from zero to several metres, and may last from a few days to years.

Wind is an extremely important climatic element in the Alpine ecoregion. As noted above, snow cover is linked to prevailing westerly winds. Wind is also important in increasing evapotranspiration. Although precipitation is higher in the Alpine than any other ecoregion, strong winds likely result in a very large moisture deficit except in well protected areas or sites where groundwater discharges or snow fields supply meltwaters. Desication of vegetation is enhanced by wind especially when the ground is frozen.

ECOLOGICAL CONDITIONS

The Alpine is characterized by low-growing vegetation. Arboreal species seldom occur except in protected sites. When arboreal species occur above forest-line they are deformed and stunted. Alpine fir, Engelmann spruce, whitebark pine, and alpine larch are the commonly occurring species.

Ogilvie (1969, 1976), Baig (1972), and Craig (1977) have recognized zonation patterns within the Alpine Ecoregion. This zonation is too detailed to be recognized or mapped at an ecoregion level of analysis, although it provides a logical scheme to describe some of the vegetation and

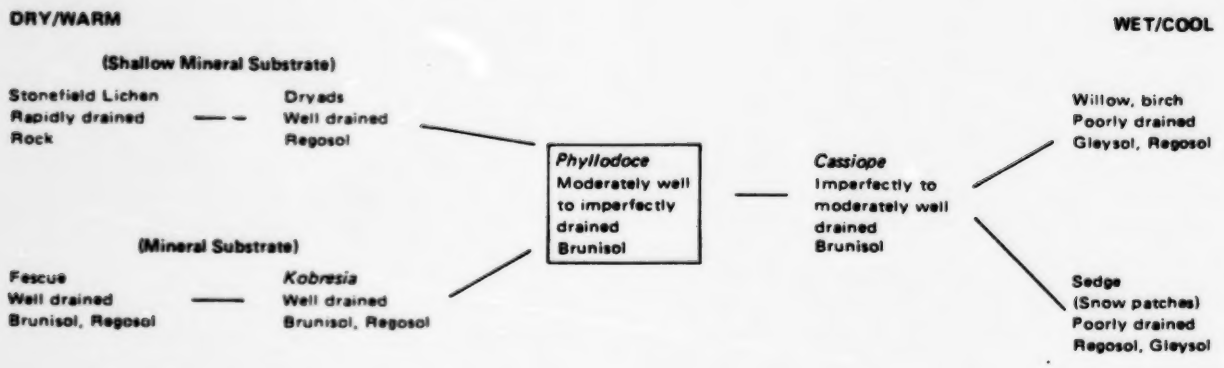


Figure 16.
Alpine Ecoregion – Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

ecological diversity found in the Alpine Ecoregion. At the lower elevations (Lower Alpine) willow and dwarf birch ("Tall Shrub") communities and "islands" of krumholz occur. This area is somewhat warmer than the area at higher elevations. Low and middle elevations (Middle Alpine) are characterized by relatively continuous "heather and snowbed communities", while higher elevations (Upper Alpine) are poorly vegetated due to the cool summer temperatures and exposure to wind. Rocky outcrops and stonefield lichen communities are typical of the Alpine Ecoregion. Glaciers occur in the highest terrain where snow accumulation exceeds ablation.

Figure 16 represents a composite and generalized scheme of common plant communities found in the Alpine. This synthesis was based on the work of several researchers (Beder 1967; Baptie 1968, Ogilvie 1969; Bryant and Scheinberg 1970; Hrapko 1970; Baig 1972; Knapik, Scotter, and Pettapiece 1972, Trottier 1972; Broad 1973; Hodgson 1972, Johnson 1975; Kuchar 1975; Jacques 1976; Corns and Kojima 1977; and Crack 1977). A factor that appears to be one of the most important in determining plant community distributions is snow cover. Snow cover distribution is influenced by wind, slope angle, aspect, and terrain configuration. In general, snow depth increases as wind speed and frequency decrease.

Phyllodoce communities were among the more commonly mentioned, but not necessarily the most areally extensive of Alberta's Alpine plant communities (Figure 16). These communities are usually found on moderately well drained mineral substrate. Poorly developed soils are typical of Ecoregion 7. Snow accumulation on *Phyllodoce* sites is usually only moderate.

Mesic to wet sites are dominated by *Cassiope* communities. This community tends to occur on sites which are somewhat protected from the wind resulting in snow accumulation. Willow communities are commonly found in association with seepage from late summer snowmelt and streams. Soils are usually imperfectly to poorly drained Gleysols or Regosols. Sedge communities are found on sites with deep snow accumulation which melts late in the summer.

The cool ground temperatures of the Alpine Ecoregion do not promote the formation of well developed soils. Regosolic soils are the typical soils on sedge and dryads sites. The better developed Brunisolic soils are associated with *Phyllodoce, Cassiope, Kobresia* (a sedge-like plant), and fescue communities.

Stonefields are vegetated by lichens. These plants grow attached to the face of rocks. *Rhizocarpon* and *Omphaldiscus* are the most abundant lichens found on stonefields.

Grass and *Kobresia* are found on southerly aspects where a mineral substrate occurs (Figure 16). The daily temperatures are warmer on these aspects than any other Alpine locations. Fescue grass usually dominates the vegetation cover, although numerous shrub and forb species are present.

PRESENT USES

The Alpine Ecoregion is probably one of the most fragile and unique ecological systems in Alberta. Watershed management and protection, recreation activities, and wildlife habitat are important concerns and uses of this area (Eastern Slopes Interdepartmental Planning Committee 1977).

Ecoregion 8 – Boreal Mixedwood

Ecoregions 8, 9, 10, 11, and 12 are all components of the Boreal climatic zone. Approximately 43% of the province is

Figure 17.
Location of Boreal Mixedwood Ecoregion.

composed of the Boreal Mixedwood which makes it the largest ecoregion (Table 1). Ecoregion 8 occurs in the north-central portion of Alberta and abuts the Aspen Parkland on the south, Boreal Foothills on the southwest, and Boreal Northlands on the north (Figure 17). The 290,000 km^2 of Mixedwood vegetation in Alberta is half of the total extent recognized by Rowe (1972) in Canada. Mixedwood forests extend from the eastern portion of northern British Columbia to the southwestern corner of Manitoba. The Boreal Mixedwood Ecoregion extends over a variety of landforms and topography. Relief is generally subdued although localized occurrences of greater relief occur.

This ecoregion was separated from Ecoregion 4 along the Black Chernozem/Luvisol soil boundary, from Ecoregion 9 on species composition of the vegetation, and from Ecoregion 11 on soil and vegetation characteristics (Table 3). Ecoregion 8 is primarily composed of deciduous forests which are underlain by Luvisolic soils. White spruce and balsam fir are the potential climax species on mesic sites.

Because the Boreal Mixedwood Ecoregion is a large area, few comprehensive studies have been completed. Also, the ecoregion has not been inventoried due to its northern location away from populated areas and poor accessibility. The Boreal Mixedwood has only recently gained economic significance.

The Boreal Mixedwood Ecoregion has a low energy climate with short winter days and long summer days. Despite the length of summer days, potential solar energy available at the ground surface is lower than ecoregions at lower latitudes. Another important aspect of this ecoregion's climate is its continentality. More than 70% of the total yearly precipitation occurs during the summer which is higher than any other ecoregion in the province. Generally, July is the wettest month which reflects the influence of the mid-Alberta storm track. Furthermore, of all ecoregions discussed previously, this ecoregion has the coldest mean winter temperature and largest range between the mean winter and summer temperatures.

CLIMATIC CONDITIONS

The Boreal Mixedwood can be broken into three subregions based primarily on summer precipitation: Dry Mixedwood, Moist Mixedwood, and Wet Mixedwood (Figure 18). The driest of these includes the Peace River district and a strip which parallels the northern boundary of the Aspen Parkland (Map 1). Climate stations which express the modal climatic conditions of this subregion are Beaverlodge and Athabasca. The Moist Subregion of the Boreal Mixedwood is best represented by the climate stations at Thorsby, Doucette Lookout, and Economy Lookout. The wettest portion of this ecoregion has be delineated in the upland

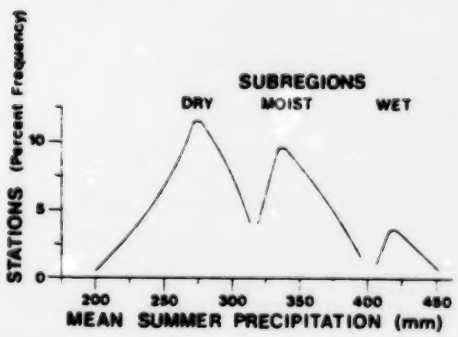


Figure 18.
Percent Frequency of Mean Summer Precipitation Classes in the Boreal Mixedwood.

area between Fort McMurray and Heart Lake Lookout (Mostoos Uplands).

Summer climate data in this ecoregion are extensive: winter climate data are scarce. This makes interpretations of winter and annual precipitation tenuous. Based on available data this ecoregion has a mean annual precipitation of 440 mm with a range of 350 to 520 mm. This is somewhat misleading as the wet subregion likely has a mean annual precipitation total over 600 m.

The Moist Mixedwood Subregion covers a large portion of Ecoregion 8 (Map 1). The mean summer precipitation in this subregion is about 320 mm with a range from 300 to 380 mm. The Wet Subregion is an area with summer precipitation between 380 and 440 mm. This subregion is associated with the mid-Alberta storm track which brings very high precipitation during summer months. The Dry Mixedwood Subregion has mean summer precipitation from 200 to 300 mm. Generally speaking, the Dry Subregion is drier, and Moist Subregion is wetter than the Aspen Parkland. Both the Aspen Parkland and Boreal Mixedwood have precipitation maxima in July.

The mean summer temperature for the Boreal Mixedwood is 12.0°C, with a range from 10.5 to 14.0°C. As can be seen from Table 2 and Figure 19 this is considerably cooler than the Aspen Parkland. We should note here that the portions of the Aspen Parkland with temperatures similar to the Boreal Mixedwood are associated with the foothills portion of the Aspen Parkland. In the Dry Subregion mean summer temperatures are over 12.0°C, whereas in the Wet Subregion they are below this value. The Moist Subregion has mean summer temperatures that range from 10.5 to 13.5°C.

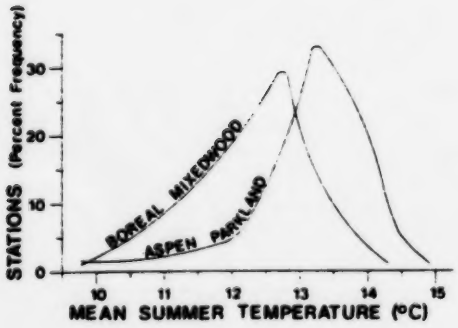


Figure 19.
Percent Frequency of Mean Summer Temperature Classes in the Boreal Mixedwood and Aspen Parkland Ecoregions.

The mean freeze free period of 85 days for the Boreal Mixedwood is 10 days shorter than for the Parkland. Generally, the freeze free period is greater than 85 days in the Dry Subregion, while it may be as low as 50 days in the other two subregions. The mean number of growing degree days in the ecoregion is 1190 which is 70 lower than for the Aspen Parkland. Much of the Dry Subregion has growing degree day totals similar to the Parkland. The climatic moisture deficits in the Boreal Mixedwood are high (Table 2). These are likely overestimated because the Thornthwaite method of calculating potential evapotranspiration is based on mean temperatures and does not take into account solar radiation.

The Boreal climatic zone of Canada is known for extremely low winter temperatures. This ecoregion is dominated by very cold, dry Arctic air masses during winter. The mean December to February temperatures is -15.5°C with a range of -11.5 to -23.5°C. There is a notable decrease with increasing latitude. This mean is 3.0°C cooler than the Aspen Parkland.

Precipitation from October to April amounts to 170 mm. Snow cover in the Boreal Mixedwood is uniform as wind does not play a large role in redistribution (Table 2). Snow cover lasts for an average of 150 days which is longer than any of the previously discussed ecoregions. Chinooks are not important to the winter climate of the Boreal Mixedwood.

ECOLOGICAL CONDITIONS

The Boreal Mixedwood Ecoregion is dominated by aspen with secondary quantities of balsam poplar which occurson medium textured, moderately well drained soils (Picture 8). This ecoregion represents a transitional zone between the Aspen Parkland and mixed conifer-deciduous ecoregions to the north and west. Mature trees frequently range from 18 to 24 m in height. The understory vegetation is varied although species such as reed grass, wild rye, pea vine, vetch, roses, dogwood, willows, and saskatoon are common components. Secondary plant succession is primarily by white spruce, although balsam fir occurs in old growth stands.

Gray Luvisolic soils develop in association with the modal vegetation and reflect the cool moist climate and conditions beneath the tree canopy. An eluviated Ae horizon (+10 cm) which overlies a clay accumulation horizon (Bt) typifies the soil profile sequences in this area.

Jack pine communities are another common vegetation type of the Mixedwood Ecoregion (Figure 20). They occur on sandy parent material such as outwash or sand dunes. The largest concentration of this vegetation type lies south

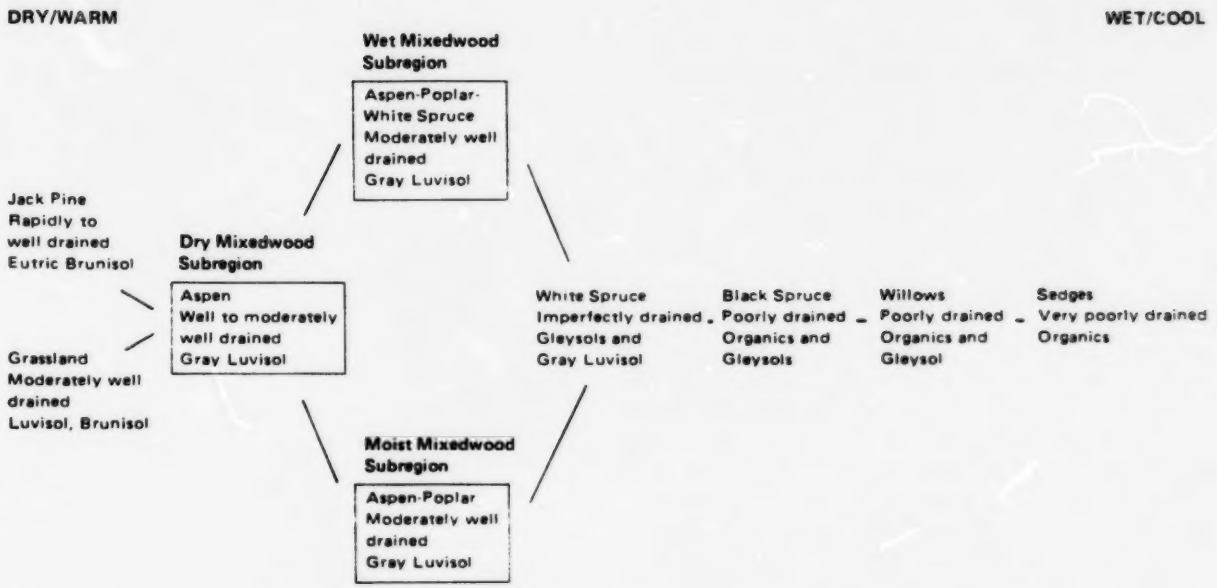

DRY/WARM
WET/COOL
Wet Mixedwood Subregion
Aspen-Poplar-White Spruce Moderately well drained Gray Luvisol
Jack Pine Rapidly to well drained Eutric Brunisol
Dry Mixedwood Subregion
Aspen Well to moderately well drained Gray Luvisol
Grassland Moderately well drained Luvisol, Brunisol
White Spruce Imperfectly drained Gleysols and Gray Luvisol
Black Spruce Poorly drained Organics and Gleysols
Willows Poorly drained Organics and Gleysol
Sedges Very poorly drained Organics
Moist Mixedwood Subregion
Aspen-Poplar Moderately well drained Gray Luvisol

Figure 20.
Boreal Mixedwood Ecoregion—Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

of Lake Athabasca (Rowe 1972; Hermesh 1972). Ericaceous shrubs (blueberry and bearberry) and lichens are major components of the understory flora. The soils are primarily deeply developed Eutric Brunisols which have a poor moisture holding capacity and low nutrient status.

Poorly drained sites are vegetated by an overstory of black spruce with an understory of Labrador tea, cowberry, and mosses (Moss 1953). Growth is slow on these sites due to the poor nutrient status of the associated organic soils, high water table, lack of aeration, and low soil temperature.

The Peace-Athabasca Delta is an extensive wetland area occurring in the southern portion of Wood Buffalo National Park. The vegetation found within the Delta fits the wetter ecosystems in Figure 20. Other studies have subdivided these broad vegetation types into more refined ecosystems. (Dirschl 1970, 1972).

Of the three subregions recognized in the Mixedwood Ecoregion, the Dry Mixedwood Subregion is the most controversial, although some researchers (Rowe 1972; Alberta Recreation and Parks 1979) have considered the Dry Mixedwood Subregion as part of the Aspen Parkland, the former area is climatically different. Freeze free periods are slightly lower, growing season shorter, precipitation markedly lower, summer temperatures cooler, and incident solar radiation lower due to higher latitudes. Although aspen and grassland communities are common components of the vegetation (Figure 20), Moss (1952) examined some of the "grassland" communities associated with the Dry Mixedwood and concluded they are not related to the Aspen Parkland. Jeffrey (1961) in a study of arboreal invasion into grasslands in Wood Buffalo National Park, also suggested that these grassland areas may not be the exclusive result of climate. Soils in this subregion are sometimes humified in the upper horizons but edaphic and physiographic conditions were responsible for this development.

Moist conditions or the modal conditions of the Mixedwood Ecoregion are represented by the Moist Mixedwood Subregion. The ecological conditions associated with this area were described earlier (Figure 20).

The Wet Mixedwood Subregion represents some of the wettest climate conditions within the Mixedwood. Ecologically, the area is similar to the Moist Mixedwood although the increased moisture and cooler temperatures promote more rapid succession to white spruce than either of the other two subregions.

PRESENT USES

The uses occurring within the Boreal Mixedwood are generally more intensive than extensive. Agriculture is common along the southern fringes of the Mixedwood boundary and in the Peace River Valley. The Dry Mixedwood Subregion contains more than 85% of the land under cultivation within Ecoregion 8. In the past, this subregion

has often been classified, or considered, part of the Aspen Parkland. In terms of crop yields, this subregion has much lower yields than the Aspen Parkland Ecoregion (Peters 1977) which is probably due to lower temperatures, decreased solar radiation associated with latitude, frost damage, soils, and adverse climate at time of harvest. Forestry activities are scattered throughout Ecoregion 8. Recreational activities are commonly limited to localities where access is possible.

Ecoregion 9 – Boreal Foothills

The third largest ecoregion in Alberta is the Boreal Foothills (Table 1). This region lies on the west side of the Boreal Mixedwood Ecoregion (Figure 21) and parallel to the Rocky Mountains from the Turner Valley area northward to the British Columbia border southwest of Grande Prairie. Outliers of this ecoregion occur in the Clear and Saddle Hills, Pelican Mountains, Puskwaskau Hills (Ojamaa 1980), and Cypress Hills. These areas correspond to some of the geographical areas identified by Smithers (1961) and Rowe (1972). Work by Knight and Duffy (1967), Lesko and Lindsay (1973), Corns (1972, 1978), Anderson (1980), and Dutchak (1980) are relevant ecological studies within the Boreal Foothills Ecoregion. In general, the Boreal Foothills Ecoregion occupies plains and uplands topography which is elevated above the Boreal Mixedwood Ecoregion.

Ecoregion 9 is an ecotone between Boreal and Cordilleran vegetation. It is also a transitional zone between the deciduous Boreal Mixedwood and coniferous Boreal Uplands Ecoregions. This ecoregion is the most arboreally diverse area in Alberta. On a moderately well drained site aspen, balsam poplar, paper birch, lodgepole pine, white spruce, black spruce, and fir can occur. The criteria used to delineate Ecoregion 9 was the codominant occurrence of aspen, balsam poplar, and lodgepole pine. Luvisolic soils typically develop beneath this vegetation. The successional trends differ from previously discussed ecoregions in that both white and black spruce are successional and potential climax species on the same site.

Components of the Boreal and Cordilleran climates interact to form the regional climate of the Boreal Foothills Ecoregion. The climate is Boreal in that summers are the wettest season with a maximum during July. The Cordilleran influence is expressed by increased winter temperatures and precipitation as compared to the Boreal Mixedwood. Extremely important to the formation of this ecoregion's climate is the mid-Alberta storm track, and contributions to the precipitation by upslope conditions. The Saddle, Clear, Puskwaskau, and Cypress Hills, have somewhat lower precipitation than the main body of Ecoregion 9.

The climate is continental with a large range between summer and winter temperatures, but this range is not as great as in the Boreal Mixedwood. The precipitation regime also remains continental but a greater proportion of the yearly precipitation occurs during winter which is the result of the Cordilleran influence. The Boreal Foothills is wetter than the Boreal Mixedwood during all seasons. Recording stations which display the modal climatic conditions are Entrance, Rocky Mountain House, and Flattop Lookout.

Figure 21.
Location of Boreal Foothills Ecoregion.

CLIMATIC CONDITIONS

The mean yearly precipitation in Ecoregion 9 is 570 mm with a range from 510 to 670 mm. Although winter data are lacking in the Saddle and Clear Hills, these portions of the ecoregion probably receive approximately 450 mm of precipitation annually. Summer precipitation totals vary from 230 to 450 mm with the outliers receiving less than

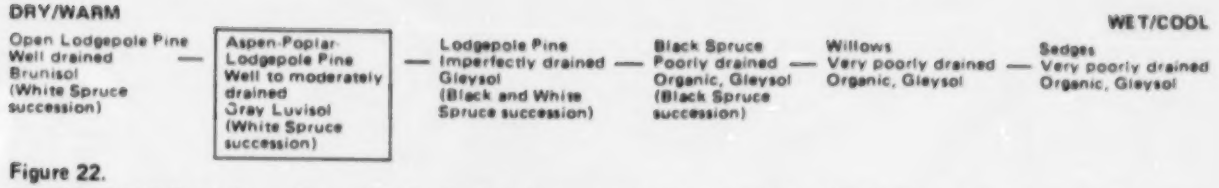


Figure 22.
Boreal Foothills Ecoregion – Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

300 mm, and the majority of the ecoregion between 300 and 400 mm. The wettest portions of this ecoregion receive precipitation amounts similar to the Moist Mixedwood Subregion. With the exception of the Alpine Ecoregion and the Wet Mixedwood Subregion, Ecoregion 9 has the highest mean summer precipitation of any area discussed so far.

The mean May to September temperature in the Boreal Foothills is 11.5°C with a range from 10.0 to 12.5°C. This is comparable to the range found in the Moist and Wet Mixedwood Subregions, but cooler than in the Dry Subregion. The coolest temperatures are found in the northern outliers. The range and mean freeze free period in the Boreal Foothills are very similar to the Boreal Mixedwood (Table 2). The lowest freeze free periods in this ecoregion are associated with valley bottom locations. From Table 2 we can see that the climatic moisture deficit is notably lower than in the Boreal Mixedwood Ecoregion. The low accumulation of growing degree days (mean 1080) precludes arable agriculture except in locally warm sites.

Winter temperatures in the Boreal Foothills are relatively warm; the mean December to February temperature is 5.0°C higher than the Boreal Mixedwood Ecoregion. This increase in winter temperature is a result of higher elevations, as the Boreal Foothills often escapes the severe cold of Arctic air masses. The December to February means are lower in the nothern outliers of this ecoregion. Mean December to February temperatures also tend to be warmer than in the Aspen Parkland. The October to April precipitation mean of 240 mm is almost 50% greater than in the Boreal Mixedwood, which is further evidence of a Cordilleran climatic influence. The core area of this ecoregion can have in excess of 20 chinooks per year, but chinooks are not important in the outliers of this ecoregion. There is a shortage of data on snow cover and depth in the Boreal Foothills. Because of the higher precipitation during winter, mean maximum snow depths are likely higher than in the Mixedwood Ecoregion. It is difficult to comment on periods of snow cover, due to a lack of data and variability of chinook activity.

ECOLOGICAL CONDITIONS

Aspen, balsam poplar, lodgepole pine, and white spruce occurring on medium textured moderately well drained Gray Luvisolic soils is considered the modal ecosystem (Figure 22; Picture 9).[11] The mixture of these species is highly dependent upon site conditions, geographical location, and recent history. In general, the deciduous components dominate. The occurrence of lodgepole pine within deciduous forest stands may be partly explained by the cooler, moister summer, and warmer winter climate of Ecoregion 9. The understory vegetation is commonly composed of Labrador tea, roses, wild rye, willows, fireweed, wintergreen, and composite species. Secondary succession is to white spruce, although black spruce occurs occasionally.

Rapidly to well drained sites and southern aspects are usually dominated by open lodgepole pine stands with bearberry, scattered herbs, and junipers. The dry site conditions result in a poor vegetation growth rate and poorly developed soil (Brunisols).

Imperfectly drained sites are dominated by lodgepole pine which is invaded by black and sometimes white spruce. A similar situation to this ecosystem occurs in the Mixedwood of Saskatchewan (Kabzems *et al.* 1976), where jack pine has a similar role to lodgepole here. The understory vegetation is dominated by mosses and Labrador tea. Gleyed Luvisols and Gleysols are common soils. This set of conditions is a good indicator of the Boreal Foothills Ecoregion, but is not areally extensive.

Black Spruce dominates poorly drained areas which are typically depressional. Organic deposits are common on the surface of these areas which maintains the ground temperature near the freezing level until the end of May or later.

PRESENT USES

The eastern edge of this area is used for agriculture (forage production, grazing, and tilled cropping). Topography and climate preclude these uses elsewhere in the ecoregion. Tree harvesting occurs throughout the area. This ecoregion has some of Alberta's most productive forest (Canada Land Inventory 1976).

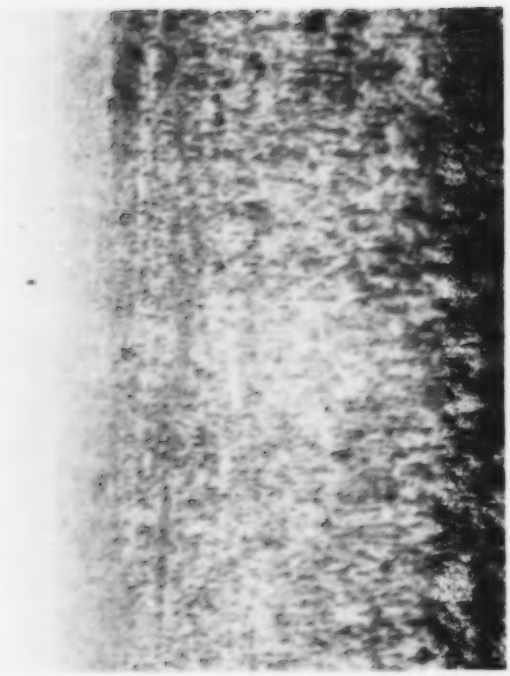
[11] Brunisolic Gray Luvisolic Soils appear to be more common in Ecoregion 9 than in other ecoregions of Alberta.

Picture 9.
Aspen, balsam poplar, lodgepole pine, and white spruce commonly grow on the same site in the Boreal Foothills Ecoregion.

Picture 10.
Coniferous forests of lodgepole pine succeeded by white and black spruce form the vegetation cover of the Boreal Uplands.

Picture 11.
White spruce forms a significant component in the ecology of the Boreal Northlands Ecoregion.

Picture 12.
The Boreal Subarctic Ecoregion has vegetation which is uncommon in other portions of Alberta.



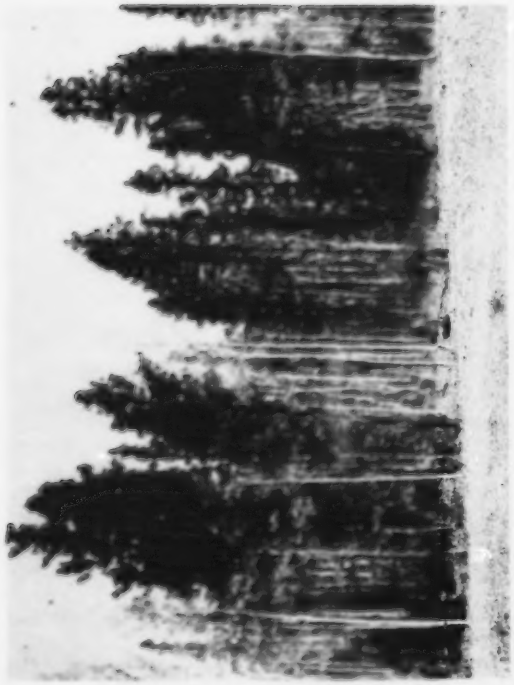


Figure 23.
Location of the Boreal Uplands Ecoregion.

Ecoregion 10 – Boreal Uplands

The Boreal Uplands is an ecosystem that occurs north of the Bow River to the Grande Cache area with outliers occurring in the Clear and Swan Hills (Figure 23). In total Ecoregion 10 occupies 4% of the province. Elevationally, it occurs below the Subalpine and above the Boreal Foothills Ecoregions. The topography associated with this area is both mountain and foothills.

Closed canopy coniferous forest dominates the vegetation (Picture 10). The ecoregion may appear similar to components of the Subalpine; however, the late successional species of the two areas are different. Potential climax species on modal sites are white and black spruce in the Boreal Uplands and Engelmann spruce in the Subalpine. These differences in secondary successional species were the criteria used to distinguish the two ecoregions. The Boreal Uplands were distinguished from the Boreal Foothills Ecoregion by the relative lack of aspen. Luvisolic and Brunisolic soils are commonly developed in Ecoregion 10. Alberta Environment Conservation Authority (1976), Achuff and La Roi (1977), Corns (1978), Dutchak (1980), and Anderson (1980) have conducted studies relating to this ecoregion.

The Boreal Uplands has a Boreal climate that is substantially modified by the Rocky Mountains, in the main body of the ecoregion, and the Swan and Clear Hills outliers. The Cordilleran influence is expressed by ameliorated winter temperatures and cooler summer temperatures as compared to other Boreal Ecoregions. The precipitation regime remains continental as all available stations receive more than 55% of their annual precipitation during the May to September period. This is a lower percentage than in the Boreal Foothills, and in the Boreal Mixedwood. The mid-Alberta storm track is an important source of precipitation in the core area and the Swan Hills outlier of this ecoregion. Furthermore, as with the Boreal Foothills much of the precipitation in this ecoregion occurs during upslope conditions. Climate stations that display the modal summer temperature conditions are Swandive and Deer Mountain Lookouts. Modal summer and yearly precipitation are represented by Clearwater Ranger Station and Swandive Lookout.

CLIMATIC CONDITIONS

The mean yearly precipitation in Ecoregion 10 is 570 mm which is equal to that of the Boreal Foothills. The range in precipitation is twice that of the Boreal Foothills at 440 to 740 mm. The driest values are in protected valleys in the Front Ranges and in the Clear Hills outlier. Summer precipitation varies from 290 to 470 mm with a mean of 380 mm. This range is much greater than found in the Boreal Foothills Ecoregion but modal and mean values are similar. The wettest areas of this ecoregion are similar to the Wet Boreal Mixedwood Subregion. As with other Boreal ecoregions July is the month of maximum precipitation.

The mean May to September temperature in the Boreal Uplands is 10.0°C with a range of 8.5 to 11.5°C. Summer temperature is very important in distinguishing the Boreal Uplands from the Boreal Foothills in the Rocky Mountains. The mean May to September temperature of 11.0°C corresponds very closely to the boundary between the two ecoregions. The Boreal Foothills does have stations with mean May to September temperatures below 11.0°C, but these are limited to outliers in the Clear and Saddle Hills (Figure 24).

There is a large range in the freeze free period (105 to 20 days) with the longest periods obtained from high, exposed sites. The cool summer temperatures depress the accumulation of growing degree days to a mean below 800.

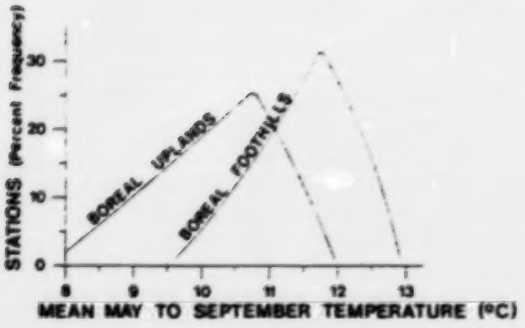


Figure 24.
Frequency of Mean Summer Temperature Classes in the Boreal Foothills and Boreal Uplands Ecoregions.

The climatic moisture budget is notably lower than in the Boreal Foothills and much of the ecoregion likely has a climatic moisture surplus over the May to September period, although this is not shown in Table 2.

The Boreal Uplands has a mean December to February temperature of -10.0°C which is very similar to the Boreal Foothills. The means are probably lower in the Clear Hills outliers. Chinooks are not an important factor in the winter climatology of this ecoregion, except in the Athabasca and Saskatchewan River Valleys. The mean October to April precipitation in this ecoregion is about 240 mm. There is a lack of data on snow depth in this ecoregion but the mean period of snow cover is probably near 140 days and the mean maximum depth is probably over 50 cm.

ECOLOGICAL CONDITIONS

Lodgepole pine dominates the overstory vegetation on moderately well drained substrates in the Boreal Uplands Ecoregion (Figure 25). The cool climate severely restricts the growth of deciduous species such as aspen and balsam poplar. Secondary succession is by white and black spruce. Brunisolic and Luvisolic soils are common on modal sites.

The understory vegetation is composed of fewer species than the Boreal Foothills Ecoregion. The cool mesoclimate and cool microclimate created by the tree canopy does not promote the development of a diverse herbaceous understory. Alder, wintergreen, aster, mosses, twinflower, and wild rye are among the common species.

Imperfectly drained sites are dominated by lodgepole pine which is succeeded by black spruce. Mosses and ericaceous shrubs commonly dominate the understory and ground cover. The imperfect drainage causes gleying or mottling of the soil profile and organic matter accumulation due to reducing conditions.

Black spruce dominates poorly drained depressional areas. These sites have a high water table throughout most of the year. Organic accumulations are common due to the drainage conditions and low oxygen availability. Such sites have a poor nutrient status and are usually acidic. Mosses, Labrador tea, horsetails, dwarf birch, willows and sedges commonly form the understory species composition. Organic and Gleysolic soils develop on these bog sites. The conditions within these bogs are similar to those in other Boreal ecoregions.

Well to rapidly drained sites are characterized by open stands of lodgepole pine dispersed among scattered grasses and shrubs. These communities are usually located on southerly exposures where insolation and evapotranspiration are high.

PRESENT USES

The Boreal Uplands is used primarily for wood fiber production, although watershed management is an important consideration. Other activities such as agriculture are severely restricted due to the cool and short summers.

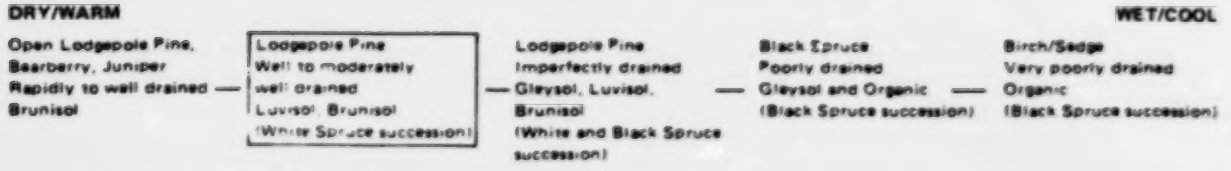


Figure 25.
Boreal Uplands Ecoregion – Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

Figure 26.
Location of Boreal Northlands Ecoregion.

Ecoregion 11 – Boreal Northlands

The Boreal Northlands Ecoregion occurs in the northern portion of the province (Figure 26). It occupies approximately 47 500 km^2 which makes it the fourth largest ecoregion in Alberta. The main units occur north of the Boreal Mixedwood (approximately 58° 30'N) although outliers occur at the upper elevations of the Buffalo Head Hills and Birch Mountains. Ecoregion 11 conforms approximately to a soil temperature zone recognized by the Soil Research Institute (1975). The Boreal Northlands Ecoregion corresponds to the High Boreal recognized in the adjoining N.W.T. (Zoltai 1979). Two forest regions identified by Rowe (1972) occur within the Boreal Northlands Ecoregion. These two units were combined because of the similar climate, although a distinct difference is apparent in the vegetation structure. This difference is attributed to geomorphic factors, (i.e. exposure of Canadian Shield rocks) rather than to climate.

Mixed deciduous and coniferous forest dominate moderately well drained sites. White spruce is the potential climax species. Boreal Northland soils are dominated by the Luvisolic Order (Lindsay, Pawluk, and Odynsky 1960). Ecoregion 11 is distinguished from the adjacent Boreal Mixedwood by the increased abundance of white spruce. The presence of only sporadic pockets of permafrost and a closed canopied overstory distinguishes the Boreal Northlands from Ecoregion 12.

The Boreal Northlands Ecoregion topography is subdued except near the Caribou Mountains and Cameron Hills. The east side of this ecoregion is composed of shield rock, the central area is dominated by coarse textured parent materials, and the western section is predominantly covered by fine to medium textured deposits (Lindsay, Pawluk and Odynsky 1959, 1960).

The Boreal Northlands Ecoregion is located in the northern extreme of the Boreal climate zone, and is therefore strongly influenced by the Arctic climatic zone. The climate of this ecoregion is to a large part latitudinally controlled. The angle of incidence of solar radiation is low during all seasons and snow cover lasts for an extended period of time. Ecoregion 11 has a continental climate and is dominated by dry air masses during all seasons. This ecoregion is colder and receives less precipitation than the Boreal Mixedwood. There are elevational trends to cooler, wetter conditions in summer, and probably warmer conditions during winter on Watt Mountain, Birch Mountains, and the Buffalo Head Hills. There are no major storm tracks associated with this ecoregion. Wadlin Lookout is typical of the outliers, while Fort Smith, N.W.T., is a climate station typical of the main portion of the ecoregion.

CLIMATIC CONDITIONS

There is a distinct lack of long term climate data in Ecoregion 11. As a result much of the following discussion is inferred from data in the Northwest Territories and from climatic maps (Government and University of Alberta 1969; Powell and MacIver 1978). Mean annual precipitation ranges from 300 to 450 mm. Values in the Buffalo Head Hills and Birch Mountains are at the wetter end, while drier values are found further north. Mean summer precipitation varies from 180 to 340 mm. The outliers of this ecoregion receive over 300 mm, whereas the northern portions receive less than 200 mm. The latter have a mean May to September precipitation total very similar to portions of the Short and Mixed Grass Ecoregions. July is the month of maximum precipitation.

The mean May to September temperature in the Boreal Northlands is 11.0°C, approximately 1°C lower than the Boreal Mixedwood. The range is from 10.0 to 12.0°C with

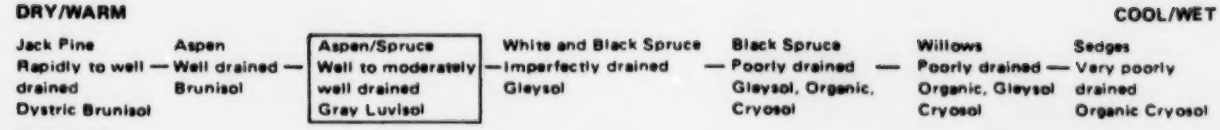


Figure 27.
Boreal Northlands Ecoregion – Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

the higher values found in the Hay and Slave River valleys. The growing degree day accumulation is approximately 1050. The mean July temperatures range between 14.0°C and 16.0°C. Summer temperatures are relatively warm due to the low elevation, but as mentioned previously this is a very low energy environment. The mean freeze free period for the ecoregion is approximately 85 days, which is considerably lower than the adjacent Dry Mixedwood Subregion.

The main portion of the Boreal Northlands has colder winters than the outliers. The mean December to February temperatures range from -23.5 to -24.5°C which are colder than any station in the Boreal Mixedwood. The Boreal Northlands outliers are likely somewhat warmer but there are no winter data available. Mean October to April precipitation is 160 mm which is similar to that calculated for the Boreal Mixedwood. The mean length of snow cover is 185 days, which is much longer than for any ecoregion except portions of the Subalpine and Alpine. This is due to the low angle of incidence of solar radiation and long winter season associated with the dominance of cold Arctic air. The mean maximum depth of snow is 55 cm.

ECOLOGICAL CONDITIONS

Mixed aspen and white spruce forests growing on moderately well drained, medium textured Luvisolic soils are considered the representative ecosystems for this Ecoregion (Figure 27). White spruce appears to form a much more dominant component of this ecoregion than it does in the Boreal Mixedwood (Picture 11).

The understory species composition is dominated by buffaloberry, wild rose, cowberry, willows, fireweed, bunchberry, toad flax, wintergreen, wild rye, twinflower, and mosses. Mosses appear to be more common in the deciduous forest of Ecoregion 11 than in the Boreal Mixedwood.

Stable aspen communities are usually located on coarser textured soils (Brunisols and some Luvisols) that are moderately well to well drained. These sites have somewhat warmer soils than those on medium textured parent materials. Although mixed aspen-spruce communities develop from aspen stands, stable aspen communities have a slower rate of spruce invasion. The understory vegetation of the latter communities is similar to mixed aspen-spruce communities, except mosses are less abundant.

Jack pine communities dominate rapidly to well drained sites and are comparable to jack pine stands of the Boreal Mixedwood. Dystric Brunisols with thick eluviated Ae and podzolized Bm horizons typify the soils.

Imperfectly drained sites are dominated by white spruce with secondary quantities of black spruce. These stands commonly have a nearly continuous ground cover of feather-mosses while herbaceous species are very limited in coverage. Microclimatically, these stands are cool and humid. Lack of oxygen results from the impeded drainage conditions which gives rise to Gleysolic soils.

Black spruce communities characterize poorly drained topography. Dwarf birch, Labrador tea, alpine bearberry, and mosses form the understory vegetation. Organic and Gleysolic soils commonly develop on black spruce sites. Permafrost may also occur where the microclimate or organic horizons are sufficient to maintain frozen ground throughout the year. Permafrost may develop from the continuous build up of ice as a result of organic matter insulation.

PRESENT USES

Forestry, hunting, and trapping activities are amongst the uses occurring within this area. A large portion of the ecoregion is contained within Wood Buffalo National Park.

Ecoregion 12 – Boreal Subarctic

The Boreal Subarctic Ecoregion occurs on the following highland areas in the northern portions of Alberta: Cameron Hills, Caribou Mountains, and Buffalo Head Hills (Figure 28). In total it is an area covering approximately 26 500 km^2 or 4% of the province. Widely spaced black spruce with a moss ground cover underlain by permafrost characterizes Ecoregion 12 (Picture 12). The Boreal Subarctic is distinguished from other ecoregions by the presence of discontinuous permafrost and the sparse overstory. Some areas lack tree cover. The Boreal Subarctic Ecoregion represents an ecosystem near the northern latitudinal and altitudinal forestline. Frozen organic deposits or Organic Cryosols are common soils. The topography does not have a large range of relief. Thermo-karst features which create micro-topography are relatively common in this area.

Figure 28.
Location of Boreal Subarctic Ecoregion.

Lindsay, Pawluk, and Odynsky (1959, 1960) recognized these areas in early soil surveys; however, Rowe (1972) in his map of forest regions did not separate this area from the surrounding forests. The study of Ecoregion 12 has been hampered by poor access and remote location. The Soil Research Institute (1975) considered the soil temperatures of this region very cold (Subarctic), the coldest in Alberta.

Ecoregion 12 occurs near the northern limits of the Boreal climate zone, but because of the high elevations associated with the area it expresses characteristics of Arctic climates which occur further north. This is expressed by decreased summer temperatures. The climate is Boreal in that July is the month of maximum precipitation, and precipitation totals are much higher than those in an Arctic climate.

The climate of this ecoregion is continental, but the range between summer and winter temperatures is not as great as in the Boreal Northlands. It is likely the winter temperatures are warmer than in the Boreal Northlands due to upland locations. Ponton and Whitesand Lookout display summer temperatures deemed representative of this ecoregion. Winter data are lacking.

CLIMATIC CONDITIONS

Climatic data are almost non-existent for this ecoregion so the following discussion is mostly qualitative. The mean annual precipitation in this ecoregion is likely between 400 and 450 mm. Summer precipitation is approximately 300 mm.

The mean May to September temperature in this ecoregion is 10°C, whereas all stations in the Northlands were above 10°C. The mean July temperatures tend to be below 13°C in the Boreal Subarctic. No data are available on freeze free period, but it is likely less than 60 days. The cool temperatures keep growing degree day accumulations below 750.

Winter temperatures are probably more moderate than those of the Boreal Northlands. When continental Arctic air masses dominate this system, as they frequently do, temperatures tend to increase with elevation. Chinooks do not play a role in the winter climate. Due to the longer winter, the period of snow cover is likely greater than in the Boreal Northlands. The mean maximum snow depth is also greater. The salient feature of this ecoregion is the cool summers with low energy input which does not allow the soil to warm above freezing.

ECOLOGICAL CONDITIONS

The typical or characteristic vegetation and environmental conditions of Ecoregion 12 do not fit the "modal" concept (i.e. characteristic vegetation which occurs on medium textured soils that are moderately well drained) as applied in other ecoregions of Alberta. Open black spruce stands with an understory of mosses, *Sphagnum*, cloudberry, and lichens (*Cladina* spp.) typify the area (Figure 29). This vegetation occurs on organic deposits which are commonly frozen (Cryosolic Order) throughout the year. These ecosystems occupy approximately 50% of the landscape. Ice is usually within 50 cm of the ground surface. Mosses aid in maintaining permafrost by acting as an insulator.

Poorly drained sites lack arboreal cover but have similar shrub, herb, and ground vegetation as described above.

Areas near stream drainage systems are commonly dominated by both white and black spruce. Permafrost is either deeper (>50 cm) on these sites or lacking.

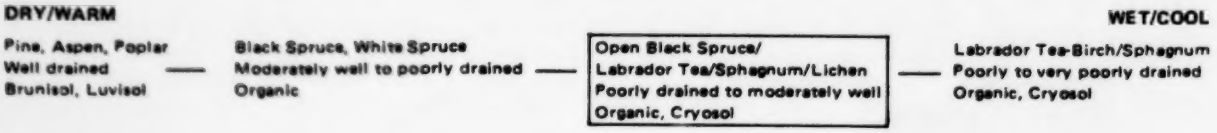


Figure 29.
Boreal Subarctic Ecoregion – Ecosystem distribution along an environmental gradient. Modal ecosystem delineated by the box.

Raised mineral soil and steep southerly exposures are vegetated by pine (lodgepole or jack pine), aspen, and/or poplar. Such sites are usually the most xeric and have no permafrost. Soils are poorly developed due to the cool climate. These sites occupy less than 15% of the ecoregion.

Due to the cool climatic conditions most arboreal species are considerably reduced in abundance when compared to other Boreal Ecoregions.

PRESENT USES

Uses of this ecoregion are limited by the permafrost, cool summers, and poor access. The most important land use occurring is probably wildlife habitat.

DISCUSSION

Resource Evaluation

Ecoregion evaluation for various land uses is difficult because a regional climate alone does not dictate the productivity of an ecoregion. However, a regional climate can direct the productivity of the landscape with abiotic factors modifying its effects. The following is a brief summary of the climatic constraints imposed on various land uses within the 12 ecoregions of Alberta. The degree of climate limitations used in the following evaluations are only interpreted for the province on a relative basis.

AGRICULTURE

The number of accumulated growing degree days, length of freeze free period, total May to September precipitation, and severity of moisture deficit are some of the more important climatic factors which promote or limit grain (wheat, oats, and barley) crop production. Of the twelve ecoregions in Alberta, the Fescue Grass and Aspen Parkland Ecoregions have the most promising climatic regime, although moderate temperature and moisture limitations do occur (Table 4). The Mixed and Short Grass Ecoregions have only slight or no limitations of temperature for the production of one crop per year but moisture factors are severely limiting. This problem is sometimes compensated for by irrigation.

Temperature and energy deficiencies are a significant problem in the forested ecoregions for cereal crops, although the Boreal Mixedwood and Boreal Foothills Ecoregions may be suited to perennial crops such as alfalfa or other cool loving crops. Within these areas the Dry Mixedwood Subregion appears to be the most favorable area for grain production. The remaining ecoregions have sufficient limitations to severely reduce the feasibility of such agriculture.

FORESTRY

Moisture availability is a severely limiting factor for white spruce growth in grassland, Aspen Parkland, and Montane Ecoregions; and Dry and Moist Mixedwood Subregions (Table 5)[12]. White spruce occurs within some of these ecoregions only where edaphic and/or microclimatic conditions have modified the effects of the macroclimate to increase moisture availability. The Wet Mixedwood Subregion probably does not suffer from a severe climatic moisture deficit due to the greater quantity of precipitation that it receives.

The Wet Mixedwood Subregion and Boreal Foothills Ecoregion have the most favorable climates for white spruce growth in Alberta, although moderate climatic limitations do occur in these areas (Table 5). These ecological units likely have the most extensive areas of good tree growth.

The Boreal Uplands and Boreal Northlands Ecoregions have less favorable climatic conditions for white spruce growth than the two previously mentioned ecosystems. The Boreal Northlands has a moderate to severe limitation of summer precipitation, while the Boreal Uplands has a moderate to severe limitation for growing degree days. Even though the low accumulation of heat likely reduces tree growth rates, the decreased growth may not be a major problem for commercial harvesting within the ecoregion because of the increased density of coniferous trees.

[12] White spruce is used for evaluation because it is the most widespread commercial tree species in Alberta.

Table 4

AGRICULTURAL CLIMATIC LIMITATIONS – TILLED CROPS (Wheat, Oats, and Barley)[13]

Ecoregion	Growing Degree Days	Freeze Free Period	May to September Precipitation	Climate Moisture Deficit
Short Grass	S	S	V	V
Mixed Grass	S	S	M	V
Fescue Grass	M	S	S	M
Aspen Parkland	M	S	S	M
Montane	V	M-V	M	M
Subalpine	V	V	S	M
Alpine	V	V	S	–
Boreal Mixedwood	M	M	S	M
Boreal Foothills	M	M	S	S
Boreal Uplands	V	M-V	S	S
Boreal Northlands	V	M	M	–
Boreal Subarctic	V	V	S	–

	Growing Degree Days	Freeze Free Period (days)	May to September Precipitation	Climate Moisture Deficit
Slight to No Limitation (S)	> 1300	> 90	> 275 mm	0 to -100 mm
Moderate Limitation (M)	1300 - 1050	90 - 75	275 - 225 mm	-100 to -200 mm
Severe Limitation (V)	< 1050	< 75	< 225 mm	< -200 mm

[13] Based on Canada Land Inventory 1978; Resource Analysis Branch 1972; and Strong and Anderson 1980.

Table 5

CLIMATIC LIMITATIONS FOR CONIFEROUS TREE GROWTH (White Spruce)[14]

Ecoregion	Growing Degree Days	Mean No. of May Killing Frosts	May to September Precipitation	Climate Moisture Deficit
Short Grass	S	S	V	V
Mixed Grass	S	S	M-V	V
Fescue Grass	S	S	M	V
Aspen Parkland	S	S	M	V
Montane	S-M	M	M	V
Subalpine	V	V	M	M-V
Alpine	V	V	M	–
Boreal Mixedwood	S	M	M	V
Boreal Foothills	S	M	M	M
Boreal Uplands	M-V	M	S-M	S
Boreal Northlands	S	M	M-V	(M)
Boreal Subarctic	(M-V)	V	M	–

	Growing Degree Days	Mean No. of May Killing Frosts	May to September Precipitation	Climate Moisture Deficit
Little or No Limitation (S)	> 1040	< 5	> 375 mm	> -50 mm
Moderate Limitation (M)	1040 - 875	5 - 10	375 - 250 mm	-50 to -100 mm
Severe Limitation (V)	< 875	> 10	< 250 mm	<-100 mm

[14] Source: Strong and Anderson (1980).

The least favorable climates for white spruce growth occur in the Alpine, Boreal Subarctic, and Subalpine Ecoregions. These ecoregions have severe temperature limitations. Commercial tree harvesting in the two former ecoregions is non-existant while white spruce does not generally occur in the Subalpine. White spruce is replaced by Engelmann spruce which is a commercial species and more tolerant of the cooler climate of this ecoregion.

RECREATION

Climate is an important physical parameter that influences an area's capability to sustain various outdoor recreational activities. Weather is also directly related to the quality of the recreation experience. The evaluation of climate suitability for recreation is based on work by Masterton, Crowe and Baker (1976) and Bennett (1977).

The Short and Mixed Grass Ecoregions have slight or no limitations for active summer and winter outdoor recreational activities based on mean temperatures (Table 6). However, there are severe limitations for winter activities due to the short period of snow cover. These two ecoregions have the lowest capability for winter recreation in the province. They have moderate limitations for passive activity such as beach use during summer due to cool temperatures. Despite this they have the highest capability (i.e. highest summer temperatures) of any ecoregion in the province.

The Fescue Grassland and Aspen Parkland have moderate limitations for summer active recreation and severe limitations for passive activities due to coolness. The Fescue Grass Ecoregion has severe limitations for winter recreation due to a lack of snow cover compared to the Aspen Parkland which has a moderate limitation. The warmer winter conditions in the Fescue Grassland relative to the Aspen Parkland give it a slight to moderate limitation for winter activities.

The climate of the Montane, Subalpine, and Alpine Ecoregions has rather severe climate limitations for summer recreational activities. Although this should be considered in land use planning, other components of the physical environment makes these areas extremely desirable for summer recreation. The Montane has a moderate limitation for winter recreation due to a lack of snow cover and a moderate limitation due to temperatures. The Subalpine has slight or no limitations for snow cover and winter temperatures which make it one of the best climates for winter recreation in the province (Table 6). The Alpine Ecoregion has a moderate limitation due to cold temperatures. These two ecoregions also have the highest snowfall of all ecoregions and the highest number of days suitable for skiing, snowmobiling and snow making.

The Boreal Mixedwood has moderate to severe limitations for summer recreation due to cool temperatures. Considerably fewer days are suitable for passive or active summer activities as compared to the grassland and Aspen Parkland ecoregions. The Boreal Mixedwood has only slight to moderate limitations for snow cover and moderate limitations for winter activities due to temperature. This ecoregion has some of the highest number of days suitable for skiing or snowmobiling in the province. During April and November the southern portions of the ecoregion may be snow free. The remainder, however, may have as many as 70% of the days between mid-November and mid-April suitable.

The Boreal Foothills and Uplands Ecoregion have limitations for summer recreation due to coolness, but they are not as severe as in the Subalpine and Alpine. In terms of winter recreation the Boreal Foothills and Uplands have few climatic limitations. These two ecoregions are not as preferable for downhill skiing as the Subalpine and Alpine due to lower snowfall totals.

The Boreal Northlands and Subarctic Ecoregions have moderate to severe limitations for summer recreational activity due to cool temperatures. These two ecoregions have long periods of continuous snow cover, but temperatures are so low that they have severe limitations for outdoor recreation from December to February. However, during mid-November and mid-April, these ecoregions have widespread capability for winter outdoor recreation.

UNGULATES

Wildlife species habitat is difficult to evaluate due to the diversity of species, their mobility, and the effects of human disturbance. However, if trends are similar to those found in the southern Rocky Mountains of Alberta (Strong and Vriend 1980), ungulates tend to favor the warmest ecoregions within their local geographical distribution during winter. The warmest climatic conditions are important for obtaining the best thermal cover and snow free areas for exposure of food. In Alberta, the Montane Ecoregion may be the most important area for winter range because it has the warmest winter temperatures (Table 2). Other areas within a colder ecoregion may be used for similar reasons but only because they are the warmest available. For example, steep southerly aspects may serve a similar purpose.

Summary

The Prairie Ecoprovince (Ecoregions 1, 2, 3 and 4) is characterized by a late summer moisture deficit which promotes herbaceous vegetation growth and restricts

Table 6
CLIMATIC LIMITATIONS FOR RECREATION[15]

Ecoregion	SUMMER		WINTER	
	Active	Passive		
	Mean May to September Temperature	Mean May to September Temperature	Length of Continuous Snowcover	Mean December to February Temperature
Short Grass	S	M	V	S
Mixed Grass	S	M	V	S
Fescue Grass	M	V	V	S-M
Aspen Parkland	M	V	M	M
Montane	M	V	M	M
Subalpine	V	V	S	S
Alpine	V	V	S	M
Boreal Mixedwood	M	V	S-M	M
Boreal Foothills	M	V	S-M	S
Boreal Uplands	M-V	V	S	S
Boreal Northlands	M	V	S	V
Boreal Subarctic	M-V	V	S	V

	Active		Passive			
	Mean May to September Temperature		Mean May to September Temperature		Length of Continuous Snowcover	Mean December to February Temperature
Slight or No Limitation (S)	14 - 18°C		18 - 22°C		<125 days	-8 to -12°C
Moderate Limitation (M)	18 - 22°C	or 10 - 14°C	14 - 18°C	or 22 - 26°C	125 - 150 days	-4 to -8°C or -12 to -16°C
Severe Limitation (V)	22 - 26°C	or 6 - 10°C	10 - 14°C	or 26 - 30°C	>150 days	0 to -4°C or ≤ -16°C

[15] Summer active – bicycling, hiking, fishing, team sports, tennis
Summer passive – walking, picnicing, beach use, family camping
Winter active – skating, cross country skiing, alpine skiing, snowmobiling - after Bennett (1977).

arboreal species, except in the Aspen Parkland which is transitional to forested ecoregions. The amount of available moisture for plant growth increases from Ecoregion 1 to 4, inclusive. This increased availability is only partially the result of increased precipitation. Temperatures tend to decrease from Ecoregion 1 to 4 as a response to the east to west increase in elevation and the northward increase in latitude. This plays a role in reducing evapotranspiration and moisture availability is increased.

Ecoregions 1, 2 and 3 receive maximum precipitation in June; however, Ecoregion 4 has a July maximum. The severity of the late summer moisture deficit is reduced by a July maximum and allows an increase in woody species, particularly aspen.

The Cordilleran Ecoprovince (Ecoregions 5, 6, and 7) is dominated primarily by the effects of vertical rather than horizontal climatic changes. With rapidly increasing elevations, temperatures decrease and precipitation increases. Winter precipitation is much greater than that in other ecoprovinces. Associated with the complex topography are orographic precipitation, escape from cold dense arctic air masses, increased influence of maritime air masses, increased winds, high variability of chinooks, and strong temperature gradients. All of these factors play an important role in the ecology of the Cordilleran Ecoprovince. The variety of landscapes combined with the numerous climatic conditions produces ecological diversity. The microclimatic conditions may be created by changes in just one variable such as aspect.

The Montane Ecoregion occurs at the lower elevations of this ecoprovince on some of the warmest winter sites in Alberta. These warm winter sites are created by warm air being channeled from British Columbia into Alberta through major east-west valleys, and by protection from cold Arctic outbreaks.

The Subalpine Ecoregion is less affected by factors influencing the Montane. Summers are shorter and cooler due to the increased elevations. One of the most obvious differences in the Subalpine as opposed to much of Alberta is the lack of deciduous forest stands. Due to the cooler temperatures (mean May to September 10.5°C), high frost frequency, and short growing season, deciduous trees can only survive on warm sites such as steep south aspects.

The principles outlined for the Subalpine generally hold true for the Alpine Ecoregion, the difference being one of degree. However, the climate is so severe that coniferous forests which dominate at lower elevations are an atypical component of the vegetation. The Alpine is not modified by chinooks due to its high elevational location, but is strongly influenced by winds. Winds cause desication through high evapotranspiration and physical damage to exposed vegetation. Alpine vegetation distribution is strongly related to the effects of wind and snow cover. Much of the vegetation occurs on wind protected areas resulting from topographic configuration.

The Boreal Ecoprovince is a forested area characterized by a dominance of deciduous forest with secondary succession by spruces. The climate of this area is controlled by the high latitude and a general decrease in elevation from south to north. Due to latitude this is a low energy environment. This tends to increase moisture availability for the vegetation.

Two distinctive climatic pathways have developed in response to the topographic and locational modification of the Boreal Ecoprovince climate. The first pathway involves Ecoregions 9 and 10, and is related to increased elevation in the Rocky Mountains. The Cordilleran influence is significant within this portion of the Boreal Ecoprovince. Increased precipitation, decreased summer temperatures, and increased winter temperatures are among the most salient features. In the Boreal Uplands the summer temperatures average less than 10.5°C which results in a decreased composition of deciduous trees and a dominance of conifers. This is similar to Ecoregion 6. The Boreal Foothills Ecoregion is warmer and has a significant deciduous component which is mixed with conifers. Boreal Mixedwood vegetation represents even warmer summer climatic conditions and a deciduous forest dominancy.

The second pathway is composed of a latitudinal and elevational sequence from the Boreal Mixedwood through the Boreal Northlands to the Boreal Subarctic Ecoregion. The Boreal Northlands is moister than the Mixedwood due to increased latitude and decreased temperatures. This area has a mean summer temperature near 11.0°C which suggests that white spruce will play a more important role in the vegetation of this ecoregion than in the Boreal Mixedwood. When elevations are increased significantly the mixed aspen-spruce vegetation of the Boreal Northlands gives way to subarctic vegetation (Boreal Subarctic). If it were not for the decreasing elevations with increasing latitude, the majority of northern Alberta would have a cooler climate and be covered by vegetation tolerant of cool conditions (i.e. low density needle leaved trees) with stunted growth.

In summary, the ecoregions of Alberta are all broad ecotones. Grasslands grade from the most arid to the more moist. Ecoregion 4, the Aspen Parkland, is a transition zone between the grasslands and the forested ecoregions. Within the forested ecoregions the trend is for a gradation from deciduous to coniferous forest. Aspen is the principal deciduous species and only appears to be dominant where the mean May to September temperatures is above 10.5°C. Ecoregions 6, 7, 10, and 12 are below this temperature while Ecoregion 11 is near or at the 10.5°C isotherm. Conifers (pine and spruce) dominate in cooler climates due to their tolerance to cooler temperatures and their frost hardiness. Under the most severe climatic conditions forest gives way to alpine or subarctic vegetation (Ecoregions 7 and 12).

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APPENDIX I

CLIMATIC DATA SOURCES BY ECOREGION

	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
SHORT GRASS ECOREGION									
AES/AFS – Climate Stations									
Bindloss	50 41	110 10	640	X	X				
Bow Island River Development	49 52	111 22	800	X	X	X			
Brooks	50 35	111 54	760	X				X	
Brooks I	50 34	111 54	760	X	X	X			
Brooks Horticultural Station	50 33	111 51	760	X	X	X	X		
Brooks One Tree	50 38	111 47	740		X				
Duchess	50 44	111 54	760		X				
Empress	50 57	110 00	610	X	X	X		X	
Foremost	49 29	111 27	880	X	X	X			
Groton	49 12	111 20	910		X				
Hays	50 06	111 48	780	X	X	X			
Jenner	50 43	111 10	760	X	X	X		X	
Manyberries CDA	49 07	110 28	930	X	X	X	X	X	
Medicine Hat Airport	50 01	110 43	720	X	X	X	X	X	X
Oyen[16]	51 27	110 29	780		X				
Pollockville	51 05	111 36	750	X	X	X		X	
Rainier	50 23	112 02	760	X					
Ralston	50 15	111 10	770		X				
Scotfield	51 35	111 21	760		X				
Seven Persons	49 53	110 53	760		X				
Sibbald	51 28	110 15	720	X	X	X			
Suffield Airport	50 16	111 11	780	X	X	X	X	X	X
Taber	49 47	112 07	810	X	X	X		X	
Vauxhall	50 04	112 06	780	X	X	X		X	
Vauxhall CDA	50 03	112 08	780	X	X	X	X		
Whitla	49 52	111 03	840	X	X	X		X	
Winnifred[16]	49 54	111 12	830	X	X				
MIXED GRASS ECOREGION									
AES/AFS – Climate Stations									
Claresholm	49 56	113 45	1050		X				
Claresholm Waterworks	50 01	113 43	1018	X	X	X		X	
Coaldale	49 44	112 38	860	X					

	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
Consort CDA	52 02	110 48	770		X				
Consort Wades	51 51	110 46	750	X	X	X		X	
Coronation	52 07	111 27	790	X	X	X		X	X
Craigmyle	51 39	112 10	840	X	X	X			
Drumheller	51 28	112 43	690	X	X	X			
Drumheller Andrew	51 30	112 54	720		X				
Fort MacLeod	49 43	113 24	950	X	X	X		X	
Fort MacLeod Standoff	49 32	113 20	990		X				
Gleichen	50 53	113 03	910	X	X	X		X	
Hanna	51 38	111 55	820	X	X	X		X	
Lethbridge Airport	49 38	112 48	920	X	X	X		X	X
Lethbridge CDA	49 42	112 47	900	X	X	X	X		
Magrath	49 25	112 52	980	X	X	X		X	
Milk River	49 10	111 32	980	X	X	X			
Naco	51 43	110 48	730	X	X	X		X	
Queenstown	50 36	112 59	940	X	X				
Raymond	49 27	112 42	960	X	X	X		X	
Strathmore	51 03	113 25	960	X	X	X		X	
Vulcan	50 32	113 04	990	X	X	X		X	
Wastina Hemaruka	51 42	111 07	790	X	X	X		X	
FESCUE GRASS ECOREGION									
AES/AFS – Climate Stations									
Acme CDA	51 29	113 25	900	X	X	X			
Caldwell	49 09	113 38	1310	X	X	X		X	
Calgary Glenmore Dam	51 01	114 06	1070	X	X	X			
Calgary International Airport	51 06	114 01	1080	X	X	X	X	X	X
Cardston	49 12	113 19	1150	X	X	X		X	
Carway	49 00	113 22	1360	X	X	X		X	
Cowley	49 41	114 07	1190	X		X			
Cowley A	49 38	114 05	1180	X	X	X		X	X
Cowley Olin Creek	49 42	114 04	1230		X				
High River	50 30	114 09	1200	X	X	X		X	
Lundbreck	49 55	114 08	1190	X	X	X		X	
Lyndon	50 01	113 53	1250	X	X				
Mountain View	49 08	113 38	1320		X				
Pincher Creek	49 30	113 57	1160	X	X	X			
Pincher Creek Town	49 31	113 58	1150	X	X			X	
Swalwell	51 35	113 21	910		X				
Three Hills	51 39	113 18	840	X	X	X		X	
Trochu Wimborne	51 51	113 28	870	X	X				
Waterton Lakes Ranger Cabin	49 07	113 51	1280		X				

ASPEN PARKLAND ECOREGION	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
AES/AFS – Climate Stations									
Alliance	52 26	111 47	720	X	X	X		X	
Amisk	52 41	111 07	700	X					
Bowden	51 59	114 01	910	X	X	X			
Brightview	52 59	113 43	820	X	X				
Brownfield	52 20	111 28	750	X	X	X			
Calmar	53 17	113 50	720	X	X	X		X	
Camrose	53 01	112 50	730	X	X	X		X	
Camrose 2	52 57	112 48	740		X				
Crossfield	51 25	114 10	1130		X				
Cochrane	51 13	114 26	1280		X				
Edmonton International Airport	53 19	113 35	720	X	X	X	X		
Edmonton Municipal Airport	53 34	113 31	680	X	X	X	X	X	X
Edmonton Namao Airport	53 40	113 28	700	X	X	X		X	
Elk Point	53 54	110 54	590	X	X	X		X	
Ellerslie	53 25	113 33	690	X			X		
Elnora	51 58	113 12	930		X				
Forestburg Plant Site	52 28	112 08	670	X					
Fort Saskatchewan	53 43	113 10	620	X	X	X			
Grande Prairie Airport	55 11	118 53	670	X	X	X		X	X
Hardisty	52 41	111 18	630		X				
Hillsdown	52 10	113 31	900	X	X	X		X	
Hughenden	52 31	110 58	690	X	X	X		X	
Kinsella Ranch	53 00	111 31	700	X					
Kitscoty	53 21	110 20	670	X	X				
Lacombe CDA	52 28	113 45	850	X	X	X	X	X	
Lloydminster	53 17	110 00	650	X	X	X		X	
Marwayne	53 36	110 14	590	X	X				
Metiskow CDA	52 24	110 35	690		X				
Mountain View Birdseye	49 07	113 44	1410		X				
Olds	51 47	114 06	1040	X	X	X	X	X	
Paradise Valley	53 07	110 21	670		X				
Pekisko	50 22	114 25	1440	X	X	X		X	
Pine Lake	52 10	113 30	940	X	X	X			
Ranfurly	53 27	111 39	690	X	X	X	X	X	
Red Deer	52 17	113 49	860	X	X	X		X	
Red Deer Airport	52 11	113 54	900	X	X	X		X	X
Rimbey	52 38	114 14	910	X	X	X			
Sedgewick	52 53	111 42	690	X	X	X		X	
Springdale	52 48	114 18	910	X	X	X		X	
Stettler	52 19	112 42	820	X	X	X		X	
Trochu Equity	51 45	113 12	890	X	X	X		X	
Trochu 2	51 50	113 13	870		X				

	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
Turner Valley	50 43	114 21	1230	X	X	X		X	
University of Calgary	51 05	114 08	1110	X					
Vegreville[16]	53 29	112 03	630	X	X	X			
Vegreville CDA	53 29	112 02	640	X	X				
Vermilion Airport	53 21	110 50	620	X	X	X		X	X
Vermilion Union	53 17	110 41	660		X				
Viking	53 06	111 47	680	X	X	X		X	
Viking North	53 13	111 43	700	X					
Vilna	53 58	112 01	640	X	X	X			
Warwick	53 19	111 59	610	X	X				
Wetaskiwin	52 58	113 20	760	X	X	X		X	
Willow Creek Ranger Station	50 15	114 21	1480	X	X	X			
Wimborne Gas Plant	51 54	113 34	960	X					
MONTANE ECOREGION									
AES/AFS – Climate Stations									
Anthracite	51 12	115 30	1390	X	X	X		X	
Banff	51 11	115 34	1400	X	X	X	X	X	X
Beaver Mines	49 28	114 10	1290	X	X	X		X	
Castle Ranger Station	49 24	114 20	1360	X	X				
Coleman	49 38	114 35	1340	X	X				
Coleman Ranger Station	49 39	114 30	1060	X	X				
Jasper	52 53	118 04	1060	X	X	X		X	X
Kananaskis	51 02	115 03	1390	X	X	X		X	
Porcupine Lookout[16]	49 54	114 01	1780	X					
Porcupine Ranger Station[16]	49 53	113 58	1660	X	X				
Sacramento Precipitation Gauges									
A01 Castle Ranger Station	49 23	114 21	1390						
A03 Gardiner Creek	49 26	114 18	1520						
A06 Mill Creek	49 22	114 12	1460						
B01 Coleman Ranger Station	49 43	114 30	1340						
B08 Cow Creek	49 42	114 17	1430						
D05 White Creek	50 03	114 16	1780						
E02 Porcupine Ranger Station	49 54	114 01	1750						
F01 East Porcupine	50 02	114 03	1370						
F02 Happy Valley	50 05	114 09	1400						
K01 Canmore	51 07	115 20	1320						
P04 Kootenay Plains	52 04	116 23	1370						
P06 David Thompson Highway	52 02	116 35	1370						

	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
SUBALPINE ECOREGION									
AES/AFS – Climate Stations									
Baldy Lookout[16]	52 33	116 07	2080		X				
Bluehill Lookout[16]	51 42	115 13	1950	X					
Highwood Ranger Station[16]	50 23	114 38	1490	X	X				
Ironstone Lookout[16]	49 34	114 28	2070	X	X				
Kananaskis Boundary R.S.	50 55	115 08	1460	X					
Lake Louise	51 25	116 10	1520	X	X	X		X	
Livingstone Gap Ranger Station	49 53	114 23	1420	X	X				
Mount Eisenhower[16]	51 15	115 57	1420	X	X				
Sheep Ranger Station	50 39	114 39	1490	X					
Waterton Lakes Belly River	49 03	113 42	1370		X				
Waterton Lakes Red Rock	49 08	114 01	1300		X				
Waterton Park Headquarters	49 03	113 55	1280		X			X	
Sacramento Precipitation Gauges									
A04 Upper Carbondale	49 24	114 30	1520						
A05 West Castle	49 17	114 23	1520						
A07 Upper Castle	49 13	114 10	1620						
A09 Carpenter Creek	49 15	114 03	1680						
A10 Bovin Lake	49 13	114 07	2070						
A11 Goat Creek	49 28	114 34	1860						
B03 York Creek	49 35	114 30	1540						
B04 Byron Creek Summit	49 30	114 18	1770						
B06 Saskatoon Mountain	49 40	114 23	1770						
B07 Vicary Summit	49 43	114 28	1800						
B10 Crowsnest Creek	49 36	114 40	1460						
B12 Allison Pass	49 45	114 34	1980						
C01 Livingstone Ranger Station	49 53	114 22	1400						
C03 Sugarloaf NE	49 57	114 31	2190						
C05 Sugarloaf W	49 57	114 32	2130						
C07 Sugarloaf SE	49 56	114 30	1880						
C09 Oldman NW	49 58	114 27	1540						
C10 Oyster Creek	50 07	114 37	1830						
C14 Coat Creek	50 05	114 25	1650						
C16 Racehorse Creek	49 50	114 37	1920						
D03 Johnstone Creek	50 12	114 25	2030						
D04 Pekisko	50 18	114 26	1540						
G01 Highwood Ranger Station	50 23	114 37	1490						
G02 Storm Creek	50 31	114 52	1750						
G03 Storm Creek Summit	50 34	114 56	2070						
G04 Trap Creek	50 28	114 27	1490						
G06 Wilkinson Creek	50 13	114 36	1770						
H01 Sheep Ranger Station	50 39	114 38	1480						

		LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
H02	Sheep River	50 35	114 48	1770						
I06	Ford Creek Summit	50 51	114 54	1830						
I07	Powderface Ridge	50 51	114 49	1710						
J03	Jumpingpound Summit	50 57	114 56	1860						
K02	Kananaskis Lakes	50 38	115 05	1680						
K06	Mud Lake	50 50	115 19	1910						
K07	Evans-Thomas	50 55	115 06	1510						
K08	Whiteman's Pass	51 02	115 18	1680						
M02	Blue Hill Lookout	51 42	115 12	1950						
M05	Scalp Creek	51 48	115 35	2040						
N04	Parks Cabin	51 54	115 45	1610						
O02	Falls Cabin	52 06	115 52	1620						
O03	North Ram Summit	52 20	116 04	1680						
P05	Brown Creek	52 44	116 38	1520						
P07	Cline River	52 09	116 30	1460						
P08	McDonald Creek	52 10	116 40	1620						
P09	Pinto Lake	52 08	116 45	1830						
P10	Siffleur River	51 57	116 21	1590						
P11	Brown Creek Headwaters	52 42	116 47	1830						
ALPINE ECOREGION										
AES/AFS – Climate Stations										
Columbia Icefield[16]		52 14	117 10	1980	X					
Forget-Me-Not Lookout[16]		50 45	114 45	2320		X				
Hailstone Butte Lookout[16]		50 12	114 27	2370	X					
Junction Lookout[16]		50 33	114 41	2240		X				
Kananaskis Lookout[16]		50 37	115 04	2070	X	X				
Kiska Lookout[16]		52 18	116 11	2070	X					
Moose Mountain Lookout[16]		50 55	114 50	2430		X				
Plateau Mountain[17]		50 14	114 31	2410	X					
Raspberry Lookout[16]		50 18	114 38	2360	X	X				
Sugarloaf Lookout[16]		49 57	114 32	2510	X					
Sacramento Precipitation Gauges										
C11	Galena Pocket	50 08	114 42	2260						
D02	Hailstone Butte	50 13	114 27	2360						
G05	Raspberry ridge	50 17	114 33	2360						
G07	Wilkinson Summit	50 12	114 29	1980						
H05	Forget-Me-Not	50 45	114 47	2290						
I03	Upper Elbow	50 40	114 58	2010						
I05	Little Elbow Summit	50 47	114 58	2180						
K05	Highwood Summit	50 35	114 58	2210						
K09	Elbow Summit	50 38	115 00	2180						

	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
P12 Chungo Lookout	52 41	116 44	2130						
P13 Onion Lake	52 07	116 10	1980						
BOREAL MIXEDWOOD ECOREGION									
AES/AFS – Climate Stations									
Algar Lookout[16]	56 07	111 47	780	X	X				
Athabasca	54 43	113 17	520	X	X	X		X	
Athabasca 2	54 49	113 32	610	X	X	X			
Bald Mountain Lookout[16]	54 49	118 55	940		X				
Battle River Lookout[16]	57 29	117 39	730	X	X				
Beaverlodge CDA	55 12	119 24	730	X	X	X	X	X	X
Birch Mountain Lookout[16]	57 43	111 51	610	X					
Bison Lookout[16]	57 07	116 30	730	X					
Blueberry Mountain CDA	55 56	119 08	730	X	X				
Buffalo Head Prairie	58 03	116 16	730	X		X		X	
Cadotte Lookout[16]	56 18	116 26	730	X					
Campsie	54 08	114 41	670	X	X	X		X	
Chisholm Lookout[16]	54 56	114 02	670	X	X				
Cleardale	56 19	119 29	670	X					
Codesa Lookout[16]	55 40	118 05	790	X	X				
Cold Lake Airport	54 25	110 17	540	X	X	X		X	
Cowpar Lookout[16]	55 50	110 23	560		X				
Deadwood Lookout[16]	56 38	117 21	610	X	X				
Debolt Ranger Station	54 56	118 04	610	X		X			
Doucette Lookout[16]	55 49	114 18	610	X	X				
Economy Lookout[16]	54 47	118 14	800	X	X	X			
Elmworth	55 04	119 40	750	X	X	X		X	
Embarras Airport	58 12	111 23	230	X	X	X		X	X
Eureka River	56 28	118 44	660	X					
Fairview	56 04	118 23	660	X	X	X	X	X	X
Fairview FSA	56 04	118 23	650	X					
Falher	55 44	117 12	580	X	X	X			
Fort Chipewyan	58 43	111 09	220	X				X	
Fort McMurray Airport	56 39	111 13	370	X	X	X		X	
Fort Vermilion CDA	58 23	116 02	280	X	X	X	X	X	
Goodfare CDA	55 16	119 46	760	X	X				
Hawk Hills Lookout[16]	57 39	117 25	610	X					
Heart Lake Lookout[16]	55 00	111 20	890	X	X				
High Level Airport	58 31	117 06	340	X					
High Prairie	55 26	116 31	590	X	X	X		X	
Hines Creek Ranger Station[16]	56 15	118 37	660	X					
Iron River	54 25	111 00	550	X	X	X		X	
Jean Lookout[16]	57 31	113 45	760	X					

	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
Keg River	57 47	117 52	430	X	X	X	X	X	X
Keg River Ranger Station[16]	57 45	117 37	410	X					
Kinuso Ranger Station	55 20	115 26	590	X	X	X		X	
Lac La Biche	54 46	111 58	560	X	X			X	
Lac La Biche Airport	54 46	112 01	570	X	X	X			X
La Corey Ranger Station[16]	54 25	110 46	580	X					
Manning Ranger Station[16]	56 55	117 36	460	X					
Marten Mountain Lookout[16]	55 30	114 42	1020	X					
May Lookout[16]	55 37	112 21	900	X	X				
McLennan CDA	55 43	116 57	620		X				
Meanook	54 37	113 21	680	X	X	X		X	
Moon Lake	53 28	114 59	760	X	X	X		X	
Muskeg Lookout[16]	57 08	110 54	650	X	X				
Muskwa Lookout[16]	56 05	114 39	620	X					
Newbrook	54 19	112 57	670	X	X	X		X	
Peace River Airport	56 14	117 26	570	X	X	X		X	
Peavine	54 04	114 55	690	X	X	X		X	
Primrose Lookout[16]	54 45	110 03	680	X					
Radway	54 05	112 54	630	X	X	X			
Red Earth Lookout[16]	56 40	115 07	610		X				
Richardson Lookout[16]	57 55	110 58	350	X	X				
Rochester	54 22	113 31	620	X	X	X			
Round Hill Lookout[16]	55 18	111 59	750	X	X				
Rycroft	55 45	118 47	610	X	X	X		X	
Salt Prairie Lookout[16]	55 40	115 30	720	X	X				
Sand River Lookout[16]	54 39	110 59	730		X				
Slave Lake Airport	55 18	114 47	580	X	X	X		X	
Smith Ranger Station[16]	55 10	114 02	560	X					
Snuff Mountain Lookout[16]	54 41	117 32	970		X				
South Wapiti Ranger Station	54 56	119 12	760	X		X			
Spirit River Ranger Station	55 47	118 50	630	X					
Stony Mountain Lookout[16]	56 23	111 14	760	X	X				
Sweathouse Lookout[16]	54 55	116 45	850	X	X				
Thickwood Hills Lookout[16]	56 53	111 39	600	X					
Thorsby	53 14	114 02	750	X	X	X		X	
Trout Mountain Lookout[16]	56 48	114 25	760	X	X				
Valleyview Ranger Station	55 04	117 16	760	X					
Wabasca Ranger Station	55 58	113 50	540	X					
Wagner	55 21	114 59	580	X	X	X		X	X
Wandering River Ranger Station	55 12	112 30	560	X					
Wanham CDA	55 44	118 24	610	X	X	X			
Watino	55 43	117 38	400	X					
Whitecourt	54 08	115 40	740	X	X	X		X	X
Whitecourt Lookout[16]	54 02	115 43	1200	X	X	X			
Whitefish Lookout[16]	56 11	115 28	610	X	X				

	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
Whitemud Lookout[16]	56 26	118 01	850	X	X				
Winefred Lookout[16]	55 20	110 12	740		X				
Worsley Ranger Station[16]	56 30	119 08	640	X		X			
Zama Lookout[16]	58 35	119 10	610	X	X				
BOREAL FOOTHILLS ECOREGION									
AES/AFS – Climate Stations									
Alder Flats Lookout[16]	52 48	114 29	1080	X	X				
Ansell Lookout[16]	53 31	116 21	960	X		X			
Brazeau Lookout[16]	53 01	115 25	1090	X	X	X			
Burnstick Lookout[16]	51 58	114 47	1220	X					
Carrot Creek Lookout[16]	53 27	115 52	1040	X	X	X			
Chedderville CDA	52 12	114 52	1040	X					
Chinchaga Lookout[16]	57 07	118 20	760	X	X				
Clear Hills Lookout[16]	56 36	119 25	930	X	X				
Cold Creek Ranger Station[16]	53 37	115 35	790	X					
Doig Lookout[16]	56 58	119 33	1220	X	X				
Eagle Lookout[16]	54 28	116 25	1040	X	X				
Edson Airport	53 35	116 27	920	X	X	X		X	
Elbow Ranger Station	50 54	114 42	1430	X	X				
Entrance	53 22	117 42	1010	X	X	X		X	
Flattop Lookout[16]	53 09	114 48	1030	X	X				
Ghost Ranger Station	51 19	114 57	1430	X	X				
Hinton	53 25	117 34	1010	X		X			
Hinton FTS	53 24	117 35	1020	X					
House Mountain Lookout[16]	55 02	115 37	1150	X	X				
Keg Lookout[16]	57 39	118 02	910	X	X				
Medicine Lodge[16]	53 33	117 00	940	X					
Meridian Lookout[16]	55 33	114 11	1010	X					
Naylor Hills Lookout[16]	57 40	117 43	730	X	X				
Notikewin Lookout[16]	56 52	118 35	760	X	X				
O Chiese Lookout[16]	52 47	115 20	1110	X	X				
Pass Creek Lookout[16]	54 14	116 50	1140	X	X				
Pelican Mountain Lookout[16]	55 37	113 34	910	X	X				
Pimple Lookout[16]	54 30	115 28	1100	X	X				
Pinto Lookout[16]	54 47	119 24	1070		X				
Puskwaskau Lookout[16]	55 13	117 30	970	X	X				
Robb Ranger Station	53 14	116 58	1130	X	X				
Rocky Mountain House (1)	52 23	114 55	970	X	X				
Rocky Mountain House (2)	52 23	114 55	1010	X	X	X		X	X
Saddle Hills Lookout[16]	55 37	119 43	960	X					
Shining Bank	53 51	115 58	830	X					
Sundre Ranger Station[16]	51 46	114 38	1130	X					

	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
Tony Lookout[16]	54 23	117 24	1040	X	X	X			
White Mountain Lookout[16]	55 42	119 14	1090		X				
Sacramento Precipitation Gauges									
I01 Elbow Ranger Station	50 53	114 42	1400						
I09 Moose Ridge	50 56	114 46	1880						
J01 Jumpingpound Ranger Station	51 03	114 44	1400						
J02 Sibbald Creek Summit	51 03	114 57	1550						
L03 Harold Creek	51 29	114 52	1360						
Q01 Shunda Ranger Station	52 29	115 47	1400						
BOREAL UPLANDS ECOREGION									
AES/AFS – Climate Stations									
Aurora Lookout[16]	52 39	115 43	1340	X					
Athabasca Lookout[16]	53 25	117 47	1630		X				
Baseline Lookout[16]	52 08	115 25	1900	X					
Berland Lookout[16]	54 15	117 24	1220	X	X				
Clearwater Ranger Station	51 59	115 14	1280	X	X				
Deer Mountain Lookout[16]	54 55	115 09	1120	X	X	X			
Goose Mountain Lookout[16]	54 55	116 04	1400	X					
Hotchkiss Lookout[16]	57 20	118 57	940	X					
Huckleberry Lookout[16]	53 59	118 11	1430	X	X				
Kakwa Lookout[16]	54 26	118 58	1210	X	X				
Lovett Lookout[16]	53 05	116 41	1440	X	X	X			
Mayberne Lookout[16]	53 52	116 40	1490	X	X	X			
Muskeg Ranger Station	53 55	118 39	1230	X					
Nordegg Ranger Station[16]	52 29	116 05	1330	X	X	X			
Obed Lookout[16]	53 34	117 30	1580	X					
Prairie Creek Ranger Station	52 15	115 18	1170	X					
Red Deer Ranger Station	51 40	115 13	1450	X	X				
Swandive Lookout[16]	54 44	115 13	1270	X	X	X			
Tom Hill Lookout[16]	53 56	116 20	1300	X					
Wolf Lookout[16]	53 09	115 54	1100	X	X				
Yellowhead Lookout[16]	53 14	117 09	1460	X	X				
Sacramentao Precipitation Gauges									
L02 Mockingbird Lookout	51 25	115 04	1910						
L04 Ghost Diversion	51 18	115 07	1600						
M01 Red Deer Ranger Station	51 39	115 12	1430						
N01 Clearwater Ranger Station	51 58	115 13	1280						
N02 Baseline Lookout	52 08	115 24	1860						
N03 Idlewilde Cabin	52 03	115 31	1430						
O01 Meadows Cabin	52 21	115 35	1340						

	LATITUDE ° '	LONGITUDE ° '	ELEVATION (m)	TEMPERATURE	PRECIPITATION	FREEZE FREE PERIOD	BRIGHT SUNSHINE	CHINOOKS	SNOW COVER
P01 Nordegg Ranger Station	52 28	116 06	1370						
P02 Chungo Creek	52 42	116 26	1370						
P03 Shundra-Baldy Lookout	52 32	116 07	2080						
Q02 Atlas Lumber	52 41	115 56	1220						
BOREAL NORTHLANDS ECOREGION									
AES/AFS – Climate Station									
Adair Lookout[16]	59 10	118 20	370	X	X				
Amber Lookout[16]	59 11	119 27	580	X					
Buffalo Lookout[16]	57 57	116 13	790	X	X				
Edra Lookout[16]	57 51	113 15	610	X					
Legend Lookout[16]	57 27	112 53	910	X					
Wadlin Lookout[16]	57 47	115 26	790	X					
Watt Mountain Lookout[16]	58 39	117 34	700	X	X				
Out-of-Province Stations									
Fort Smith Airport	60 01	116 00	210	X	X	X	X		X
Hay River Paradise Gardens	60 39	111 58	200	X	X				
Uranium City Airport	59 34	108 29	310	X	X	X			
BOREAL SUBARCTIC ECOREGION									
AES/AFS – Climate Stations									
Foggy Mountain Lookout[16]	58 41	114 59	880	X	X				
Ponton Lookout[16]	58 56	116 13	880	X					
Steen Lookout[16]	59 38	117 47	710	X					
Whitesands Lookout[16]	59 26	114 54	940	X					

[16] May to September only.

[17] Unpublished data supplied by S.A. Harris, Department of Geography, University of Calgary, Calgary, Alta.

APPENDIX II

COMMON AND BOTANICAL NAMES

Common Name	Botanical Name
Alder	*Alnus* spp.
Aspen	*Populus tremuloides*
Aster	*Aster* spp.
Bearberry	*Arctostaphylos uva-ursi*
Bearberry, Alpine	*Arctostaphylos rubra*
Bedstraw	*Galium boreale*
Birch	*Betula* spp.
Birch, Dwarf	*Betula glandulosa*
Birch, Paper	*Betula papyrifera*
Birch Water	*Betula occidentalis*
Blueberry	*Vaccinium* spp.
Buckbrush	*Symphoricarpos occidentalis*
Buffaloberry	*Shepherdia canadensis*
Bunchberry	*Cornus canadensis*
Chickweed	*Cerastium* spp.
Cloudberry	*Rubus chamaemorus*
Club-moss, Little	*Selaginella densa*
Cottonwood	*Populus* spp.
Cottonwood, Lance-leaf	*Populus acuminata*
Cottonwood, Narrow leaf	*Populus angustifolia*
Cowberry	*Vaccinium vitis-idaea*
Dogwood	*Cornus stolonifera*
Dryads	*Dryas* spp.
Fescue	*Festuca* spp.
Fescue, Idaho	*Festuca idahoensis*
Fescue, Rough	*Festuca scabrella*
Fir	*Abies* spp.
Fir, Alpine	*Abies lasiocarpa*
Fir, Balsam	*Abies balsamea*
Fir, Douglas	*Pseudotsuga menziesii*
Fireweed	*Epilobium angustifolium*
Fleabane	*Erigeron* spp.
Geranium Sticky	*Geranium viscosissimum*
Grass, Grama	*Bouteloua gracilis*
Grass, June	*Koleria cristata*
Grass, Oat	*Danthonia* spp.
Grass, Parry Oat	*Danthonia parryi*
Grass, Reed	*Calamagrostis* spp.
Grass, Rye	*Elymus innovatus*
Grass, Spear	*Stipa comata*
Grass, Wheat	*Agropyron* spp.
Heath	*Cassiope* spp.
Heath	*Phyllodoce* spp.
Horsetails	*Equisetum* spp.

Common Name	Botanical Name
Juniper	*Juniperus* spp.
Kobresia	*Kobresia* spp.
Labrador Tea	*Ledum* spp.
Larch	*Larix* spp.
Larch, Alpine	*Larix lyallii*
Larkspur	*Delphinium* spp.
Lupine	*Lupinus* spp.
Meadow Rue, Veiny	*Thalictrum venulosum*
Moss Phlox	*Phlox hoodii*
Omphaldiscus	*Omphaldiscus* spp.
Pine, Jack	*Pinus banksiana*
Pine, Limber	*Pinus flexilis*
Pine, Lodgepole	*Pinus contorta*
Pine, Whitebark	*Pinus albicaulis*
Poplar	*Populus* spp.
Poplar, Balsam	*Populus balsamifera*
Prairie Smoke	*Geum triflorum*
Rhizocarpon	*Rhizocarpon* spp.
Rose, Wild	*Rosa* spp.
Rye, Wild	*Elymus innovatus*
Sage	*Artemisia* spp.
Sagewort	*Artemisia* spp.
Saskatoon	*Amelanchier alnifolia*
Sedge	*Carex* spp.
Silverberry	*Elaegnus commutata*
Snowberry	*Symphoricarpos alba*
Sphagnum	*Sphagnum* spp.
Spruce	*Picea* spp.
Spruce, Black	*Picea mariana*
Spruce, Engelmann	*Picea engelmannii*
Spruce, White	*Picea glauca*
Strawberry, Wild	*Fragaria virginiana*
Tamarack	*Larix lariciana*
Toad Flax	*Geocaulon lividum*
Twinflower	*Linnaea borealis*
Vetch	*Vicia* spp.
Vine, Pea	*Lathyrus* spp.
Violet	*Viola* spp.
Willow	*Salix* spp.
Willow, Wolf	*Elaeagnus communtata*
Wintergreen	*Pyrola* spp.
Yarrow	*Achillea* spp.
Yellow Bean	*Thermopsis rhombifolia*

MAPS NOT

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OMISES